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ABSTRACT

"Science for the Seventies" (SFTS) is designed to aid teachers and administrators by helping them select materials from available elementary science programs, modify on-going science programs, or develop a better science curriculum. SFTS encompasses 16 televised programs which provide introductory experiences appropriate for launching a class into SFTS lessons described in this handbook. These lessons emphasize hands-on group and individual activities which involve little or no teacher science background, textbooks, and inexpensive materials. Topics covered include friction, seeds, magnification, floating, light, density, thermometers, measurement, and observation and description. (Author/DS)

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SFTS

PARTIAL EDITION
PHASE II SFTS-ITV PROJECT
This edition contains information on six intermediate level SFTS lessons.

SCIENCE FOR THE SEVENTIES

ITV - Handbook for Teachers

Phase II

SE 034 264

Pennsylvania Department of Education 1975

Produced by the
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and the
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SFTS

SCIENCE FOR THE SEVENTIES

ITV - Handbook for Teachers

Phase II

Pennsylvania Department of Education 1975

FEB 1 6 1991

FORWARD

This booklet is designed as a handbook to help teachers use six televised SFTS programs as an integral part of the related lessons from SCIENCE FOR THE SEVENTIES resource materials developed by the Pennsylvania Department of Education.

Handbook developed by: Dorothy Alfke
Robert Shrigley
Paul W. Welliver

Illustrator: David Torrence

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INTRODUCING

SFTS - ITV

One link in a chain through which

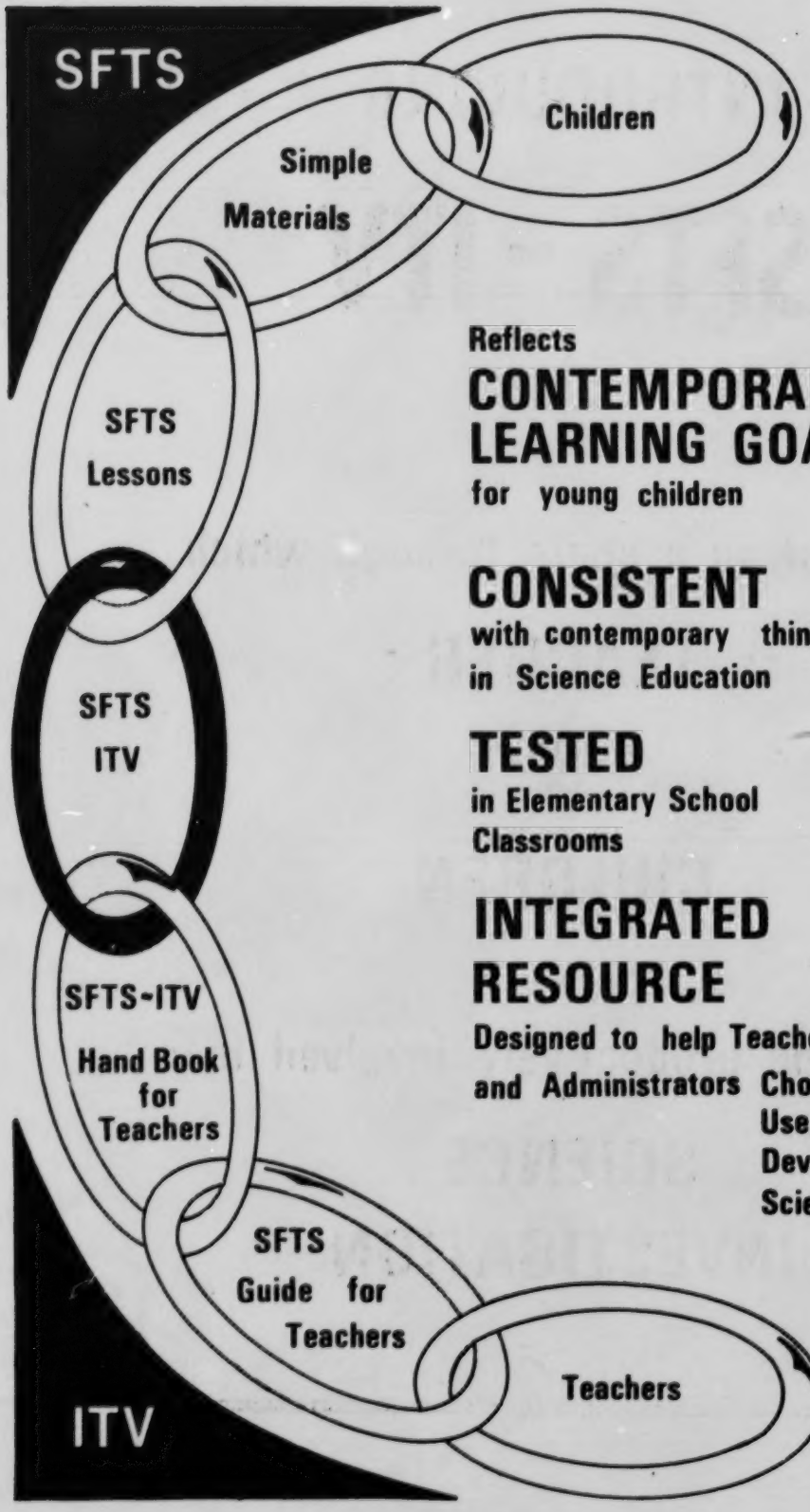
TEACHER

&

CHILDREN

become productively involved in

SCIENCE INVESTIGATION



Reflects
CONTEMPORARY LEARNING GOALS
for young children

CONSISTENT
with contemporary thinking in Science Education

TESTED
in Elementary School Classrooms

INTEGRATED RESOURCE
Designed to help Teachers and Administrators Choose, Use, and Develop Science Programs

SCIENCE INVESTIGATION

About SFTS SCIENCE FOR THE SEVENTIES

SFTS is the symbol for a statewide thrust toward providing teachers and administrators with a set of Integrated Resources for improving Elementary Science Instruction.

SFTS is not a science program.

rather

SFTS is designed to help teachers and administrators become involved in science teaching experiences which help them to:

choose more wisely from available elementary science programs

or

modify an on-going science program

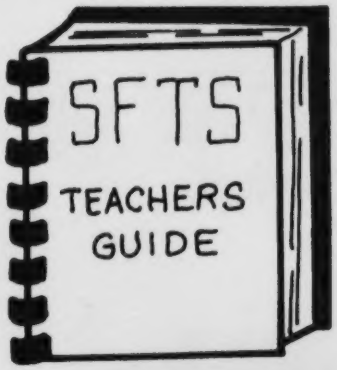
or

develop a better science curriculum.

SFTS

Encompasses

Pennsylvania Department of Education SFTS publications for Elementary Science consists of



dealing with

HOW & WHY

of contemporary Elementary Science Education

A GROWING SET of

PRIMARY and INTERMEDIATE

GRADE SCIENCE LESSONS

SFTS-ITV

Consists of

Ten 15 minute televised programs designed for use with primary children but some equally appropriate for use with intermediate grades

Six 20 minute televised programs designed for intermediate grade children

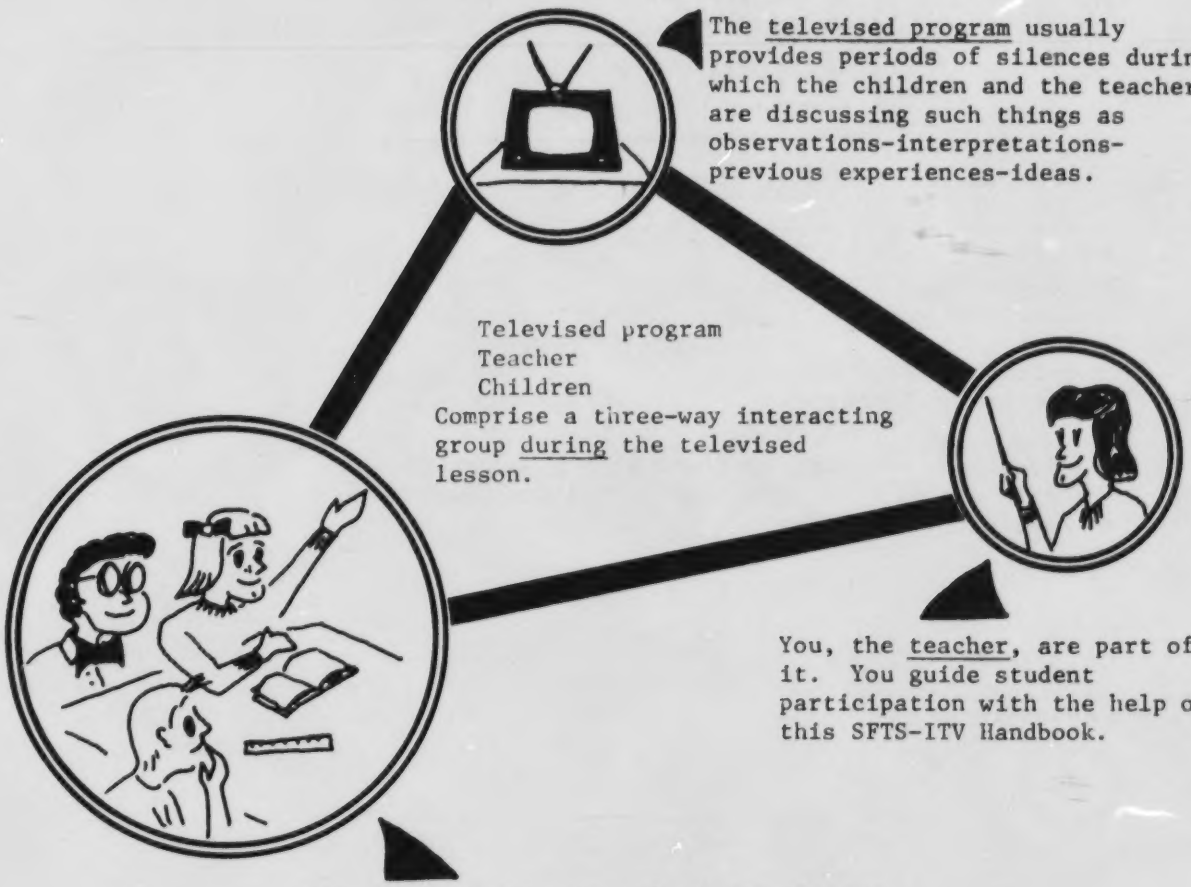
Four in-service televised programs to help teachers use SFTS-ITV with their children

Orientation to SFTS identification and discussion of the six teaching strategies

SFTS lessons where the televised lessons introduce copy of SFTS lesson introduction

SFTS-ITV charts to be used by teachers during televised presentation

SFTS-ITV
is different



The televised program usually provides periods of silences during which the children and the teacher are discussing such things as observations-interpretations-previous experiences-ideas.

Televised program
Teacher
Children
Comprise a three-way interacting group during the televised lesson.

You, the teacher, are part of it. You guide student participation with the help of this SFTS-ITV Handbook.

Your children are part of the TV program.
The TV program:

raises questions to stimulate pupil response

provides periods of silence during which children are involved in discussion or simple activities.

SFTS–ITV Programs cannot stand alone

Each is designed as a springboard for a specific lesson from the PDE publication SCIENCE for the SEVENTIES.

SFTS–ITV is built on a strategy teaching rationale

Each televised program demonstrates one or more of six basic teaching strategies considered to be central to good science instruction.

SFTS-ITV LESSONS

SFTS-ITV

Each of the 16 SFTS-ITV televised programs is an introductory experience appropriate for launching a class into a SFTS lesson.

SFTS—ITV programs cannot stand alone
Each can only be worthwhile when followed by the related SFTS lesson or a modification of that SFTS lesson.

15-minute SFTS-ITV programs

Investigating Drops
Investigating Mystery Boxes
Investigating Observation and Description
Investigating Measurement
Investigating Thermometers
Investigating Eyes
Investigating Salt and Water
Investigating Siphons
Investigating Dripping Faucets
Investigating Reflection of Light Beams

The 15-minute programs introduce SFTS lessons identified as PRIMARY lessons. All have been tested and found to be successful in K-3.

20-minute SFTS-ITV programs

Investigating Floating Things
Investigating Ice and Water
Investigating Things That Magnify
Investigating Friction
Investigating Problems of Sprouting Seeds
Investigating Heat Loss

The 20-minute programs and the related lessons are appropriate for INTERMEDIATE level but probably not for primary grade children.

However, if your students have not been exposed to on-going, investigative science curriculum, most of these lessons are appropriate for use with intermediate grade children too. Teachers can use their judgment in making adaptations. The SFTS-ITV programs have been enthusiastically judged as suitable when used with intermediate grades.

Exceptions:

Mystery Boxes - ITV program not appropriate for older children, but lesson content is.

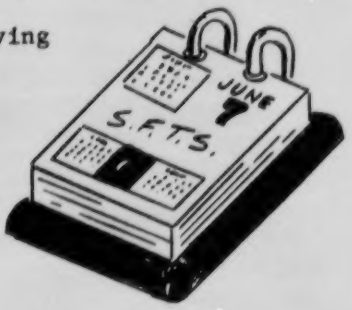
Thermometers - Neither ITV program nor lesson appropriate for intermediate level.

NOTE: SFTS-ITV lessons may be taught in any sequence.

SFTS Programs Are Classroom Tested. Throughout the development of the SFTS-ITV programs the public school classroom has been our laboratory. Before the lessons were chosen, a broad selection of SFTS lessons were taught in the Penns Valley Schools in Centre County. Elementary teachers were instrumental in the selection of science topics for taping and they were involved in decisions having to do with content, equipment and other professional concerns.

Based on experiences in the classroom, the ITV programs were selected, scripts written, and tapes produced. As each film was completed it was tested in elementary school classrooms, via closed circuit television facilities in the Altoona School District. A working copy of the SFTS-ITV teaching guide was used by each teacher involved. A number of ITV programs were also piloted in schools in the Harrisburg area.

During the pilot study, the ITV programs and the teacher's guide were evaluated by both subjective and objective means by the teachers. The pilot study evaluation served as a means of modifying the final copy of each tape and the teacher's guide.



SFTS LESSONS—SOME CHARACTERISTICS

-emphasize direct involvement of children with materials
individual and group activities

-lessons identified as to appropriate maturity level

-needed equipment is easily available

can be found in many classrooms

or

can be brought in by children

or

can be purchased inexpensively locally

-little or no teacher science content background needed

-activities lead children to generally internalize and modify knowledge rather than acquire non-conceptual verbalizations

-do not require textbooks

SFTS is not a science program. It is a resource to help teachers:

-experience interesting and worthwhile science investigation with children;

-gain insight into contemporary thinking about elementary science instruction;

choose and use existing science programs

develop local science curriculums.

USING SFTS-ITV

Know and use this SFTS–ITV HANDBOOK FOR TEACHERS

Each of the SFTS-ITV Programs

- -Launches your children and you into one of the SFTS lessons
- -Is independent, therefore can be used in any sequence

To Help You - This Handbook includes

- -The complete SFTS lesson which each SFTS-ITV program introduces
- -A teacher orientation to each SFTS-ITV program
- -A teaching strategy guide for use before and, if desired, during the program
- -A comprehensive discussion of the six SFTS-ITV teaching strategies

Discussion Period and Time	TV Image	SFTS/ITV: INVESTIGATING EYES (black & white) Final Broadcast Statement	Suggested Statements or Questions	Teaching Strategy 1
6 25 sec.	Hands clapping before face	Describe what the eyes do. Can you explain why?	Clap just once but wait a few seconds so your partner won't know just when you are going to do it.	Ideas Materials Ideas

Sample Segment from a SFTS-ITV Program Guide

VIDEO TAPES FOR TEACHERS

A set of videotapes developed to help teachers

- -use the televised introductory lessons effectively
- -gain insight into SFTS and SFTS-ITV
- -strengthen strategy skills

An Introduction

The Development

Teaching Strategies I

Teaching Strategies II

BEFORE

the SFTS-ITV program, you, the teacher should -

1. Read the section in the SFTS-ITV teacher's handbook related to the program:
   - to see the relationship between the ITV program and the SFTS lesson (reprinted in the handbook) that follows
   - to prepare for your role during the ITV presentation.

2. Collect the simple teaching materials you will need in the follow-up SFTS lessons.
   - prepare to teach the first science activity from the printed SFTS lesson

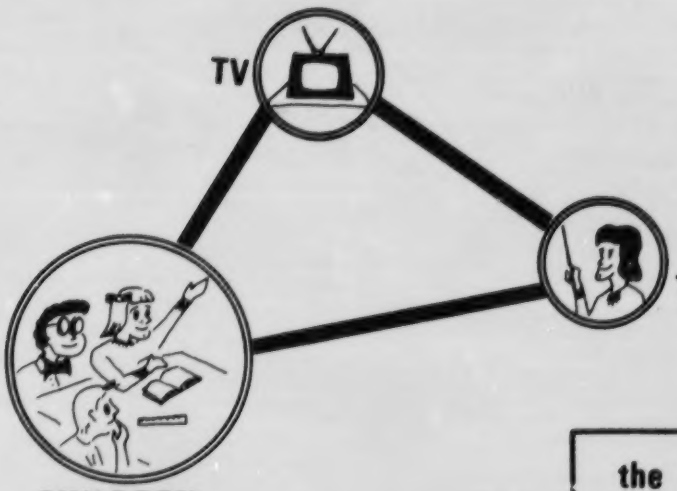
   EITHER

   - immediately following the TV program

   OR

   - the next day.

DURING the SFTS—ITV programs,



the CHILDREN

- SEATED informally so they can easily view TV screen
- FEELING FREE to
  - -respond to questions asked during TV program
  - -react to observations on the TV screen
  - -do simple science activities, if suggested by TV program

the TEACHER

- LOCATED so as to view both TV screen and children
- EQUIPPED with teacher's guide or notes
- READY to ASK appropriate questions when discussion intervals "bog down"
- READY to ANALYZE teaching techniques
- READY to MAKE mental or written notes which might be useful for the follow-up SFTS activities

the DISCUSSION BREAKS

are designed:

- -to stimulate student responses
- -to provide the teacher with a chance to practice SFTS strategies
- -deliberately brief to leave children stimulated to continue investigating and thinking in the SFTS lessons that follow

AFTER the SFTS—ITV programs

Respond to any immediate, spontaneous, relevant questions or comments from children. For some of these it may be appropriate to simply state that later activities will relate to an interest or concern expressed.

When time permits, make notes for any modifications in the SFTS lessons which might have been indicated by the children's responses during the program.

Teach the related SFTS lesson, scheduling the various activities according to professional judgment. Ordinarily the activities in the SFTS lesson should be scheduled so as to be completed within a week.

NOTE:

You, the teacher, should feel free to use your professional judgment in modifying the SFTS lessons.

MORE ABOUT SFTS

Science for the Seventies is Pennsylvania's guide for Elementary Science, published by the Pennsylvania Department of Education. The Teachers Guide and 10 lessons were published in 1970. Additional lessons have been, and will continue to be published as they are developed.

The SFTS Teachers Guide Table of Contents

What is SFTS?

Why Science For the Seventies?

Aims for Elementary Science

A Continuum for Science Education

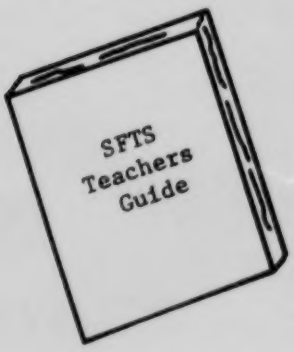
The Learning Environment

Education in the Outdoor Environment

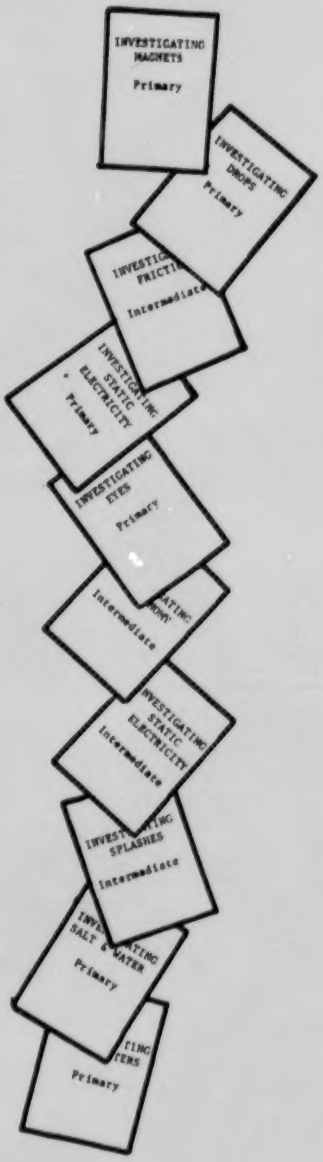
Evaluation in Science

Equipment for Elementary Science

The Relation of Textbooks to SFTS



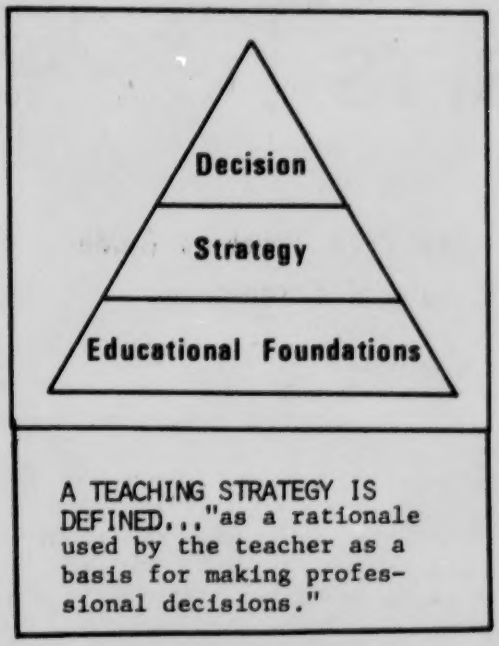
SFTS Lessons



Copies of above available from Dr. Edgar (address p. 6)

TEACHING STRATEGIES

During any school day the classroom teacher makes many important professional decisions. Such decisions influence a teacher's questioning procedure, materials used, sequence followed and general classroom climate. Rational and consistent decision making require that the teacher develop strategies to use as a guide. Sound teaching strategies for the teaching profession should be based on principles of learning, philosophic points of view, empirical research or other rational bases.


Decision
Strategy
Educational Foundations
A TEACHING STRATEGY IS DEFINED..."as a rationale used by the teacher as a basis for making professional decisions."

Each SFTS-ITV program utilizes one or more of the six teaching strategies, each based on an educational foundation and believed to support the aims of SFTS.

The strategies identified in this handbook are not peculiar to the teaching of science, but can be used in many areas of teaching and at many grade levels, including adults.

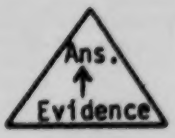
Involving you in the application of the six strategies is not for the purpose of making you proficient at applying the one and only strategy to a specific teaching situation. There is probably no discussion period in the SFTS-ITV programs where a single strategy can be selected as the only one applicable. However, you should begin to sense a strategy that is major, as compared to those which are minor, in making a decision.

The ultimate goal for including the six SFTS strategies as a part of this resource is to sensitize you to the need for a rationale, or reason, for most, if not all, decisions made in classroom teaching. It is our opinion that the basis used for decision-making in the classroom is probably the major characteristic that separates the professional from the paraprofessional.

the SFTS STRATEGY CORE

Each televised program utilizes one or more of these strategies. When they occur, they are identified in the TV lesson guide sheet by a key symbol (in the Teacher's Guide to student-teacher-TV interaction.

Teacher questions require students to arrive at an answer by examining and manipulating the materials they are using.



Responses are accepted when students use evidence from their lesson activities in observing and responding.

Student interpretations are considered acceptable, even though often they are partial or temporary conclusions, so long as the evidence and materials of the lesson support the responses.

Reasonable time is provided during discussion for observation, thought and reflection.

Teacher questions and behaviors emphasize the use of the SFTS processes including observing, classifying, communicating, measuring, inferring, predicting and experimenting.

Teacher questions encourage wider student thought and suggestions for additional investigative behavior.

1. Teacher questions and statements require students to examine and manipulate the materials they are using to arrive at their answers.

SFTS IS COMMITTED TO DIRECT EXPERIENCE, ACTIVITY CENTERED LEARNING IN SCIENCE.

Most of the science ideas that young children can conceptualize are those within the limits of direct experiences. The children's interactions with simple materials provide the source of their beginning knowledge and, in most cases, should define the limits of their knowledge. It is usually inappropriate to ask young children to generalize beyond the scope of their experiences, to formulate abstractions, or to accept abstractions.

The learning in SFTS lessons involves student interaction with materials as a means of generating both questions and answers.

THE IDEAS (ANSWERS) OFTEN LEAD TO FURTHER ACTIVITIES IN AN EFFORT TO SEEK SUPPORTIVE OR MODIFYING EVIDENCE.

WE SHOULD ENCOURAGE PRIMARY GRADE CHILDREN TO IDENTIFY AND PURSUE THE KINDS OF QUESTIONS THAT THEY WILL BE ABLE TO ANSWER BY "DOING SOMETHING" WITH "THINGS".

WE, AS TEACHERS, MUST ASK THE TYPES OF QUESTIONS YOUNG CHILDREN CAN ANSWER BY DIRECT OBSERVATIONS OF <u>THINGS</u> OR <u>BY HOW THINGS INTERACT</u>.

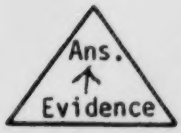
THE ABOVE THREE POINTS IMPLY:

A. "WHY" QUESTIONS ARE RARELY APPROPRIATE TO USE WITH YOUNG CHILDREN

B. TEACHERS MUST FREQUENTLY RESTATE QUESTIONS ASKED BY CHILDREN SO THAT THE QUESTIONS ARE IN A FORM WHICH LEADS THEM BACK TO OBSERVING AND INTERACTING WITH MATERIALS.

EXAMPLES

Enabling	Inhibiting
Tom, what did you do that was different from what Jean did? There must be a good reason for the different results you got.	Tom, you probably didn't leave the thermometer in the water long enough.
Why don't you both do it again to find out what caused your different observations?	Jimmie got the right answer. Andy, you must have done something wrong.
When you turn the big wheel once, what does the little wheel do?	Can you see how the big wheel is used to increase speed?
What might you do with your mystery box to try to find out how many objects are in it?	How many objects do you think the box contains?
(Child - Why doesn't my siphon work?)	
Watch me do it a few times to see if you can find out what you were doing that is different.	You didn't get all the air out of the tube. Hold one end at the bottom of the jar and the other near the top.
Some people report that the water level rose after the ice melted and others report that it stayed the same. It seems that we need to repeat the activity more carefully to answer our question.	Since we disagree on our results, I guess we need to look in some books to find the answer.
(Child - Why does the water drop roll around this piece of waxed paper and not on the glass?)	
Why don't you try some other materials to find out how drops act on them?	Because glass has a stronger attraction for water than waxed paper does.
Jimmie says he is sure there is a rock in this mystery box. Let's list all our observations and see if they all fit Jimmie's conclusion.	It can't be a rock, Jimmie, because I didn't put any rocks in the boxes.
Child - I think the salt is way up on the side of the jar because somebody must have shaken it. Teacher - That could explain it — How could we find out if shaking caused it?	No - nobody shook it. That's not the reason.



2. Teacher fosters student support of their inferences by leading them to establish a direct relationship between their ideas and the observational evidence on which they are based.

SCIENCE KNOWLEDGE IS BUILT FROM AND UPON WHAT IS KNOWN.

Science investigation is a process of seeking evidence, i.e., that which can be known. To this end, we must continually encourage children to give concrete evidence to support an inference, statement of fact, or conclusion. Observations represent what we know. Inferences are tentative explanations, predictions or conclusions which fit our limited knowledge.

Instead of "wild guesses", children should be encouraged to make "educated guesses" based on what they know to be true, i.e., evidence.

The wise teacher avoids making authoritarian decisions as to whose ideas are right. In an investigation-centered science experience. children who make statements which are in conflict with the ideas of the teacher, the book, or other children can often be at least equally right. Differences in explanations may be due to differences in observations, amount of evidence available, communication skills, etc.

When children are challenged to produce the evidence to support a statement interesting outcomes may result, i.e.:

A. They may revise their statement.

B. They may justify their "different" interpretation.

C. They may recognize a need to repeat their original activity.

D. They may identify a careless observation.

E. They gain insight into the interdependency between observations and inferences.

EXAMPLES

Enabling	Inhibiting
What did you observe that made you say that?	No, that's wrong (or that's right).
Show us what you did and what you observed that gave you that idea.	
Try doing it again to check your observations.	
Do you have a reason for saying that?	Rejecting (or accepting) an idea without giving children a chance to present their evidence.
What is your evidence for making that guess (prediction, etc.)?	Allowing children to argue a point without using observations or other appropriate evidence to defend their point of view.
Do we need more evidence before we can say that?	Accepting or inflicting abstract verbalizations for which children have no experiential foundation.
Have you had any experiences with ice changing to water or water changing to ice that might help you predict whether the water level will be higher, lower, or the same after the ice cubes melt.	Each of you make a guess whether the water level will be higher, lower, or the same after the ice melts.
Let's match your list of observations with your conclusion and see if they all support that statement.	But, that's not the right answer. This experiment is to prove that _____.

3. Student interpretations are considered acceptable (even though they are partial or temporary conclusions) as long as the evidence from their investigations and experiences support their responses.

SCIENCE IS SELF CORRECTING. THAT IS: ANY EXPLANATIONS (EVEN THOSE OF SCIENTISTS) ARE TENTATIVE AND SUBJECT TO CHANGE AS NEW EVIDENCE IS ACQUIRED.

Science knowledge is dynamic. Whenever scientists encounter new evidence, they reexamine related theories, conclusions, etc. The new evidence may cause them to strengthen, revise, or reject existing ideas.

So, too, with young children. Their science concepts evolve through a sequence of partial truths - those that are true within the limits of their experience.

Each of us can only be as right as our observations, past experience and reasoning power permit us to be. As long as we regard our ideas as dynamic - i.e. subject to modification when conflicting new evidence is encountered - knowledge evolves in a pattern that is meaningful. that reflects openmindedness, and which is in keeping with the spirit of science.

At the primary level, the child's explanations may fit his limited evidence and experience yet not be in agreement with ideas of the "experts". Any child's idea, justified by his evidence should be accepted without condescention or qualifying statements such as "but..." or "however...", etc. Teacher Responses can reflect the idea of tentativeness by taking such form as:

That seems to explain what we now know.
Does that fit all we have observed?
Is there anything else we can do to check our idea?

EXAMPLES

Enabling	Inhibiting
Child - Magnets attract only nails and paper clips, nothing else. Teacher - That agrees with our observations, so far.	Yes, magnets attract all iron and steel.
Child - The dripping water goes down the drain into the ground. Teacher - (No comment)	
(Perhaps arrange for children to visit a house under construction and revise this idea).	No, it goes through pipes to the septic tank.
Child - There are two marbles in the box because (state relevant observations). Teacher, "You have found some real good clues." (Later when children compare, three clicks may be demonstrated.)	You didn't observe very carefully. If you had you would have heard three objects bump against the side.
(Observation and Description Lesson) Child - I think the answer is the aquarium. Teacher - That fits all the clues I gave you, doesn't it. But it isn't the object I have in mind. I guess you need another characteristic. The object would fit in your desk.	No, that's not the object I have in mind. Guess again.
The candle in the jar went out because it didn't have enough air. Teacher, accept with approval.	The real reason it went out was it didn't have enough oxygen (oxygen is merely a meaningless verbalization for young children.
Child - All magnifiers must be made of something that has no coloring in it. Teacher - Accept or make neutral statement such as: It certainly seems that none of the colored objects we used were good magnifiers.	But if there is only a pale coloring in the lens it will work. Think of tinted eyeglasses.

4. Reasonable time is provided during discussion for observation, thought, and reflection.

BY INCREASING "WAIT-TIME" AFTER DISCUSSION QUESTIONS TO FIVE SECONDS, TEACHERS HAVE FOUND THAT MORE CHILDREN PARTICIPATE, THE QUALITY OF RESPONSES INCREASE, AND GREATER PUPIL TO PUPIL DISCUSSION OCCURS.

This practice involves what Mary Budd Rowe has titled "wait-time". Her research indicates that many teachers seem unable to tolerate periods of silence longer than one second during class discussion. If children are barraged with questions and pressured for immediate answers, they do not have time to involve themselves in the mental, observational and manipulative activities which are important to an investigative type science program.

Young children need time to think, to figure out, and to reconcile conflicting ideas. They need time to derive answers from observations. They need time to communicate their ideas. Discussion among children improves their communication skills. School is a place where children evolve their learning, not where they recite "right" answers.

Try to wait at least five seconds before calling on a child for a verbal contribution. Wait again, after the child's statement, to give the children in the group time to think about what has been said and to react with questions, additional information, statement of conflicting ideas, etc.

By increasing "wait-time" the talk pattern in a classroom often changes from:

Teacher-pupil-teacher-pupil, etc.
to
Teacher-pupil-pupil-pupil-teacher-pupil-pupil-teacher, etc.

Teachers might find statements similar to the following helpful in fostering effective use of wait-time.

1. I'm not going to call on anyone for a while so that each of you has a chance to think of what you want to say.

2. Think about it and raise your hand when you have an idea. I'll nod and you can put your hand down until others are ready with ideas.

3. I'll tilt the mystery box slowly several times so you can really hear the sounds and think about what they help you to know.

4. Think about what Johnny said and decide why you agree or why you disagree with him.

Process

5. Teacher questions and bheaviors emphasize the use of SFTS processes including observing, classifying, communicating, measuring, inferring, predicting, and experimenting.

THE DEVELOPMENT OF SKILLS IN USING THE PROCESSES OF SCIENCE IS BASIC TO PRODUCTIVE INVESTIGATION IN SCIENCE.

The processes listed here are selected from those identified in the SFTS AIMS as being most appropriate for children in the elementary grades.

OBSERVING

Looking
Listening
Feeling
Smelling
Tasting

CLASSIFYING

Identifying likenesses
Identifying differences
Grouping into sets

COMMUNICATING

Verbally
By Gesture
By Showing
By Drawing
By Diagrams
Listening
Questioning

MEASURING

Size
Weight
Quantity (volume)
Number

INFERRING

Using observations and past experiences to construct tentative explanations, conclusions, predictions, etc.

PREDICTING

(Extrapolating) Inferring a behavior by imagining an extension of a pattern which has been identified (by graph, table, list, etc.)

These process skills are useful in curriculum areas other than science. Many teachers report that their first and second graders gradually transfer these skills to use in subjects other than science. The process skills are important in one's role as a consumer, as a citizen, in interacting with people, etc.

Example: Discriminating between inferences and observations.

Primary grade teachers realize that children's ideas often exceed their ability to express them verbally. Because of this limitation, young children should be encouraged to use gestures, to demonstrate (with the actual materials) what they did, and to use other appropriate methods to convey their thoughts and their questions to classmates and to the teacher.

To help children grow intellectually and to grow in self-image, teachers are challenged to use all their ingenuity to:

a. convey to the child that both teacher and classmates are sincerely eager to understand what the child means;

b. avoid inferring, prematurely, the idea the child is trying to convey.

Sample teacher statements that support communication skill growth:

1. Tell us a little more about it

2. Show us what you mean

3. Would it help us to understand if you make a drawing on the chalkboard?

4. Try to say it another way

5. Jimmy, you look confused. Can you ask a question to help us explain this better for you?

6. Jane, tell us in your own words what you think Anne means. That will help Anne find out if she has gotten her idea across.

7. I'm going to say it in another way and you can see if I understand what you mean.

Open Ended

6. Teacher questions and statements encourage wider student thought and suggestions for additional investigative behavior.

OBSERVATIONS AND CHILD-CENTERED DISCUSSIONS INVARIABLY LEAD TO QUESTIONS.

Investigation type science learning is often divergent since it focuses on what children find meaningful and what children ask about their observations. Some of the questions which arise can be directly answered by further investigation.

However, we should not let children feel that they can find or understand answers to all their questions. Let's face it, they can't. Some questions may need to be modified to divert the child's interest into something which can profitably be investigated by doing something.

When children report conflicting (or seemingly conflicting) outcomes to investigations, the conflict can usually be resolved best by going back to the materials to identify the source of disagreement, e.g.: inaccurate observation, variations in procedure, legitimate differences in interpretation, etc.

Often a common class investigation leads to suggestions from the children or teacher for further investigation. These can provide opportunity for individuals or small groups to do further work at home or at school.

Open ended elementary science provides for:

a. closure on child's terms

b. creativity and divergence

c. individual differences

Examples of teacher reactions which support strategy #6:

1. Try it and see what happens.

2. Can you think of anything you can do to find out?

3. Child: "Why does it do that?"
   Teacher: "What did you have to do to make it happen?"

4. Can you think of anything else we can try to find out more about it?

5. Is there anything you might investigate at home that is related to what we have been doing?

6. Jimmie, you thought of another question while you were working on this investigation. You might want to do some investigating on your own and let us know what you find out.

SFTS LESSONS

SFTS Lessons -- Written by
- SFTS Committee
- classroom teachers
- pre-service teachers

-- Classroom tested

-- Appropriate for use in almost any science program

-- Developed to help teachers design additional lessons to develop an integrated program of their own

Current list of SFTS Lessons

Primary

Investigating Seeds and Fruits
Investigating Flowers and Fruits
Investigating Static Electricity
★ *Investigating Observation and Description*
Investigating Magnets
★ *Investigating Siphons*
Investigating Dripping Faucet II
Investigating Wheels and Gears
★ *Investigating Eyes*
★ *Investigating Drops*
★ *Investigating Reflection of Light Beams*
★ *Investigating Mystery Boxes*
★ *Investigating the Thermometer*
★ *Investigating Dripping Faucet I*
Investigating Salt and Water
Investigating Measurement
Investigating Splashes
Investigating Astronomy
Investigation Liquid in Containers
Investigating Bouncing Objects
Investigating the Passage of Light
★ *Investigating Things that Magnify*
★ *Investigating Ice and Water*
★ *Investigating Problems of Sprouting Seeds*
★ *Investigating Floating Things*
★ *Investigating Friction*
★ *Investigation Heat Loss*

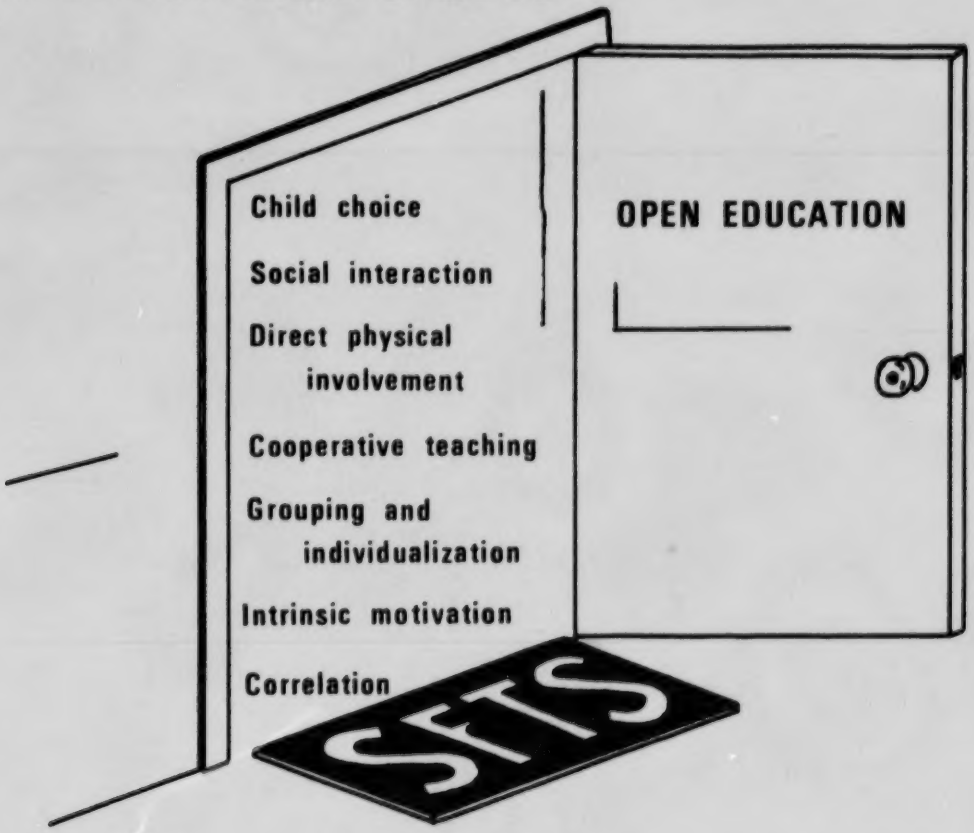
The 16 SFTS lessons for which a televised introductory experience has been developed is identified by the symbol ★

All SFTS MATERIALS are FREE upon request to teachers and administrators in Pennsylvania

Write specific request to:

Dr. Irvin Edgar, Chief
Division of Science and Technology
Pennsylvania Department of Education
Bureau of General and Academic Education
Box 911, Room 556
Harrisburg, Pennsylvania 17126

OPEN EDUCATION & SFTS



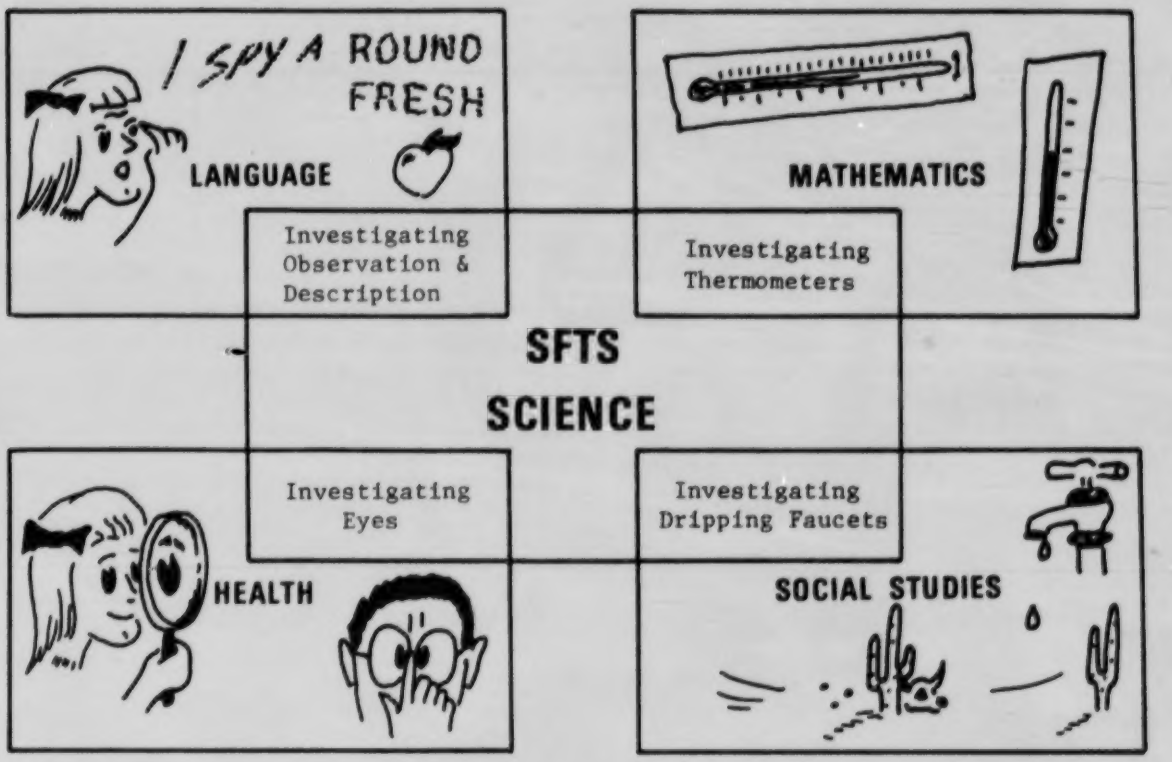
The philosophy of SFTS is quite compatible with that of open education. The televised programs are developed for large group instruction, but the follow-up activities accommodate groups of many sizes.

Children are directly involved with the materials of their environment at the same time that they are involved socially with each other and adults, both professionals and paraprofessionals.

The openness of many investigations provides the child with choice as to questions tested and materials used. Thus, investigations are designed to be self motivating.

Cooperative teaching required in such innovations as the non-graded plan and continuous progress, supports the intent of SFTS. The large blocks of a daily timetable required in cooperative teaching and the correlation of various subjects is the sort of plan that enhances the aims of SFTS.

CORRELATION: A TIME SAVER



An on-going science program in the elementary school classroom requires a spot on the daily timetable. However, many SFTS television programs (and additional printed lessons available at PDE) were developed to correlate easily with other subjects. Investigating Thermometers and Investigating Measurement are math-centered. Investigating Dripping Faucets, an ecologically-oriented lesson, would correlate well with social studies. Children write a story in this lesson, thus language is correlated. Investigating Eyes is a health lesson.

Other SFTS lessons are especially appropriate for learning centers and still others encourage open-ended investigative activities that children can do independently - some out-of-class, at home activities.

Characteristics of SFTS Lessons:

A Summary Sheet

Investigating:	Individual or small group work emphasized	Appropriate for large group instruction	Has potential for independent study (e.g., learning centers)	Investigations can easily be done at home	Mathematical skills; Measurement	Metric measurement	Graphing; diagramming	Vocabulary skills	Health related (e.g., senses)	Environmental Implications	Gamelike activities	Discrepant event; surprises
Drops	x		x	x			x				x	
Mystery Boxes	x		x	x				x	x		x	x
Observation and Description	x	x		x				x	x		x	
Measurement	x				x	x						
Thermometers	x	x			x	x	x					
Eyes	x	x							x			
Salt and Water	x		x	x	x			x				
Siphons	x		x									
Dripping Faucets	x		x	x	x					x		
Reflection of Light Beams	x	x			x						x	
Floating Things		x	x									x
Ice and Water	x		x	x			x					x
Things that Magnify	x	x	x	x								
Friction	x		x	x	x	x						
Problems of Sprouting Seeds	x		x	x								
Heat Loss	x		x	x	x	x	x			x		

ITV LESSONS

INVESTIGATING FLOATING THINGS

Television Introduction

Teacher Orientation

A major portion of the televised program involves the viewers in the observation of the floating behavior of two objects that are quite similar in appearance - a sponge and a piece of light volcanic rock called pumice. Both float in water.

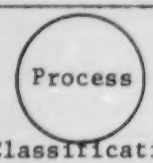
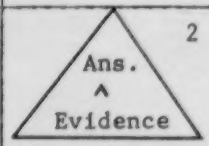
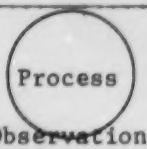
One of the major purposes of the lesson is to assist the teacher and the children in differentiating between an observation and an inference.

Observations are defined as information acquired through the use of the senses. Careful observation results in what you know as color, texture, weight, size, shape, etc.

Inferences, on the other hand, are interpretations of observations. They are what an observer believes to be justifiable integration of evidence obtained through observations. True observations are never subject to change but inferences are since they are not truths. Inferences are subject to revision as new evidence is acquired.

Inferences are important components in the search for knowledge. However, inferences present problems when pupils treat an inference as an observation. In the televised program, viewers will observe that objects A and B have holes, are similar in shape and size, etc. They could infer that the objects might be sponges, pieces of bread, sandstones, etc.

The televised program culminates with the introduction of the viewer to the SFTS lesson where an ice cube floats in one clear liquid (water) and sinks in another clear liquid (alcohol). With this discrepancy, students should then be highly motivated to seek explanation through observation and inference.

Discussion Period and Time	TV Image	SFTS/ITV: Investigating Floating Things - 20 minutes color		Teaching Strategy
		Final Broadcast Statement	Suggested Statements or Questions	
1 30 sec.	Balls, pencil, frisbee, screwdriver	Look at these objects and see if you can decide just by looking at them which will float when you put them in water. What do you think?	Which objects will float? Which do you predict will sink in the water?	
2 60 sec.	Balls, pencil, frisbee, screwdriver	What did you already know about these objects that helps to decide whether or not they will float?	What have you done with a pencil (screwdriver, ball, etc.) that helped you decide whether it will float or not?	
3 60 sec.	Three individuals collecting water samples	See how many different inferences you can come up with.	What do you think the people are doing?	
4 40 sec.	Observing objects A and B	List all the ways you observe the objects are alike and all the ways they are different.	How are objects A and B similar? How are they different? Let's list them.	
5 40 sec.	Manipulating two objects, A and B	Look and listen. See what other likenesses and differences you observe.	Now, what differences can we add to our list? How about likenesses?	
6 30 sec.	Weighing two objects, A and B	Maybe some of you would like to see if one object weighs more than the other. OK, let's see!	Which object, A or B is heavier? Which is lighter?	

Discussion Period and Time	TV Image	SFTS/ITV: Floating Things		Teaching Strategy
		Final Broadcast Statement	Suggested Statements or Questions	
7 30 sec.	Two objects A and B	Will object A float or sink? Will object B float or sink? What would you infer?	What do <u>you</u> think? Can you explain the reason for your choice?	5 Process Inferring
8 40 sec.	Two objects floating	Based on this additional information, can you make any more inferences about these objects?	What else can you say about the characteristics of A and B?	5 Process Inferring
9 40 sec.	Object B floating	Go back over all your observations and see if you can make any more inferences about object B.	Look at B closely. What else could you say about B?	5 Process Inferring

Title: Investigating Floating Things (Robert L. Shrigley)

Level: Lower Intermediate

Aims: From SFTS Toward Which This Lesson Contributes

1. The student will demonstrate competency in the use of the processes of science by (a) observing, (b) classifying, (c) inferring, (d) controlling variables, and (e) experimenting.
2. The student will pursue problems of study and state the methods for gaining the solution to these problems.
3. The student will explain basic conceptual schemes of the material world using personal experience acquired through various activities as a basis for the explanation.
4. The student will discriminate between observation and inference.

Instructional Objectives: At the conclusion of this lesson, the student will:

1. Discriminate between observations and inferences.
2. Classify observations concerning buoyance in one group and inferences in another.
3. Select and test at least one inference.

Background Information:

As water freezes it expands, therefore, becoming less dense; thus, ice floats on or near the surface of water. This is a common, everyday experience in the environment of pupils. Alcohol, on the other hand, is less dense than either water or ice; thus, the ice sinks to the bottom of a container of alcohol. This is not a common experience for children.

Water and alcohol appear to be the same liquid to the observer of this investigation who is advised to use only the sense of sight. Pupils assume both liquids to be water. However, when ice is dropped into each container of clear liquid, the behavior of the cubes differs. At this point, the pupils have experienced an obvious discrepant event.

A discrepant event is a unique teaching strategy where a phenomenon that is presented seems illogical, i.e., ice sinks when the observer expects it to float. This surprise strategy provides children with the motivation to actively seek a solution to the problem.

It is important that the teacher refrain from providing verbal clues that will short-circuit the pupils' investigation. A slip of the tongue revealing that the liquid is alcohol will probably cause the pupils to stop looking for a solution. The objective of inferring that the liquid must have different characteristics is more important than the pupils classifying liquid A as water and liquid B as alcohol.

One of the objectives of this lesson is to help students discriminate between observations and inferences. Observations in this investigation are facts derived from visual examination of the phenomena. Inferences require further investigating, testing, and measuring before they could be established as facts or rejected. The teacher should exert a real effort to help students separate children's observations from inferences. List each separately.

The focus of this investigation is not that students understand the concept of density. This concept is too abstract for most elementary school youngsters to internalize. The investigation of buoyancy

should be considered a series of readiness activities that provide students with a number of perceptions that might be recalled later when the student develops more fully his understanding of the density concept.

It is suggested that large enough quantities of liquids be used so that students can easily view them at some distance. Choosing the teacher demonstration mode of instruction, instead of small group activity was another means of keeping students some distance from the alcohol.

Total Equipment List:

Two gallon glass jars (perhaps mayonnaise jar from school cafeteria or restaurant)

Two quarts of alcohol (ordinary rubbing alcohol (isoprophyl) can be used, methanol or methyl alcohol should not be used)

Water

Ice cubes (colored with food coloring if the teacher desires)

[The equipment list for all activities is the same.]

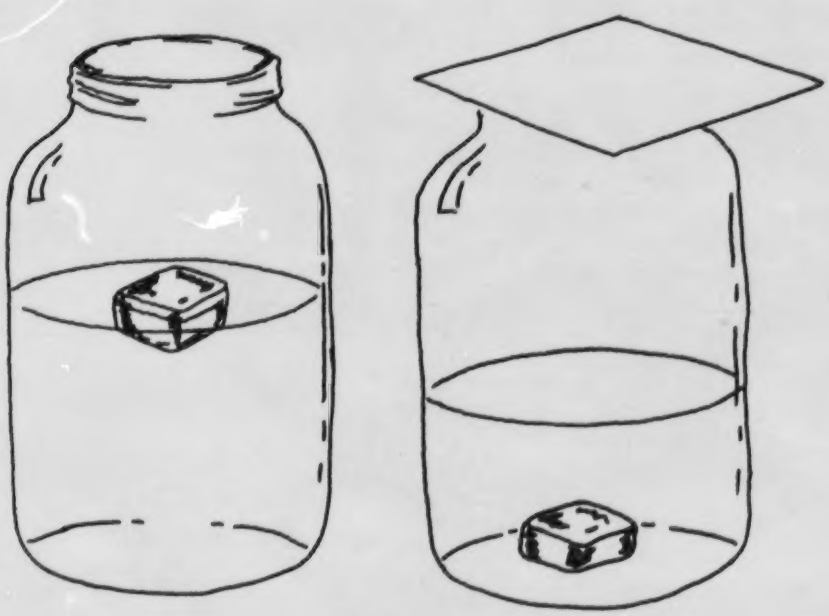
Activity 1:

1. Pour about three (3) quarts of water in a gallon glass jar. Label it "A". Pour about two (2) quarts of alcohol in another gallon glass jar. Label it "B". Place a lid or piece of cardboard on "B" to keep the odor of the alcohol from permeating the air. It is important that there be more water in "A" than alcohol in "B".

2. Ask the students to observe jars "A" and "B" and record observations. List: (1) likenesses and (2) differences.

Here is a partial list:

Observations	
(1) Likenesses	(2) Differences
1. Jars same size 2. Both containers seem to be glass	1. Levels of liquid 2. Lid on "B"; no lid on "A"



3. As the students observe you, drop part of an ice cube in "A" and a whole ice cube in "B". Ask the students to observe and make additions to their list of likenesses and differences.

Observation
Differences
Ice cube floats in "A", sinks in "B".

Up to this point, you should have insisted that they list only their observations. Now, encourage them to list some inferences that might explain the behavior of the two ice cubes. When appropriate, ask children to state an observation which suggests the inferences listed.

Inferences

1. Ice cube in "A" floated because it was smaller than ice cube in "B".
2. Ice cube in "A" floated because the liquid is deeper in "A" than in "B".
3. Liquid "A" is made of different chemicals than "B".
4. Liquid "A" is heavier than "B".
5. Ice cube sank in "B" because of the lid.
6. The ice cube sank in "B" because it was not dropped from the same height.
7. The ice cube sank in "B" because it was dropped at a different time.
8.
9.

(Children may list other inferences concerning temperature differences, melting rates, etc.)

Activity 2:

Assist the class as its members design an experiment to test one of the inferences, perhaps Inference 1: "Ice cube 'A' floated because it was smaller than 'B'." Encourage students to control the variables by giving the teacher instructions, for example, select two ice cubes the same size, drop both into liquids at the same time, from the same height, etc. The students should be asked to compare the results of their experiment with Activity 1. (They will probably note that the ice cube still floated in "A" and sank in "B" - suggesting that size must not be significant.)

Activity 3 - Competency Measure

Examine the inferences remaining on the list in Activity 1, as well as other inferences your class has added to the list. Each inference could be assigned to a small group of students for the purpose of them suggesting an experiment to test it.

Following the completion of Activity 3, each group should direct the teacher to manipulate the materials according to the experiment designed by that group. To test Inference 2, the liquid levels could be adjusted and ice cubes dropped into each container of liquid. (It would be easier to lower the water level "A" than to raise the alcohol level "B".)

Inference 3 is an example of one that students are unprepared to test. An acceptable alternative in dealing with an inference is to choose not to test it.

Other inferences placed on the list by your class should be tested before Inference 5. If the children choose to remove the lid from container "B" as a means of testing Inference 5, the odor of alcohol will permeate the atmosphere within minutes.

INVESTIGATING ICE AND WATER

Television Introduction

Teacher Orientation

This introduction is designed to provide a transition into the "science activities" which you will conduct following it. You will probably want to spread the SFTS lesson activities over several days. Emphasis in this television presentation will be placed upon introducing basic concepts and techniques leading to student instructional objectives as well as techniques that you may use to promote these desired objectives.

The major purpose of this television program is to demonstrate key techniques involved in conducting an investigation with ice and water. In the televised program a young girl observes an investigation of ice and water on her television set at home. The girl then involves herself in ice and water investigation by diagramming and recording information provided by the television presentation. The presentation is designed in such a way as to leave the girl (and the pupils in your class) with an intriging question. The question is investigated as a part of the SFTS lesson in which you can involve children following the television program. Read the SFTS lesson, "Investigating Ice and Water", on the following pages in the handbook before you start teaching the follow-up lesson.

Discussion Period and Time	TV Image	SFTS/ITV: INVESTIGATING ICE AND WATER (20 min.-color)		Teaching Strategy
		Final Broadcast Statement	Suggested Statements or Questions	
1 30 sec.	Several ice cubes in glass of water	What do you observe when the ice is placed in the water?	What things do you notice about the ice? About the water level?	5 Process Observation
2 40 sec.	Ice cubes in glass of water	How do you explain this change?	How do you explain the change in water level?	5 Process Inferring
3 30 sec.	Glass	Why do you think it is a good idea to keep a record of your observations during your investigation?	How might observations recorded now help us later in our investigation?	5 Process Inferring
4 30 sec.	Two diagrams 1-without ice 2-with ice	What information does your diagram record?	What information is contained in the diagram or what do the diagrams tell us? How many bits of information does the diagram preserve?	5 Process Communicating
5 30 sec.	Ice pushed down with fork	What do you notice happening when the ice is pushed under the water?	Look closely as the ice is pushed down. Tell us what what you see happening to the water.	2 Ans ^ Evidence
6 30 sec.	Diagram of fork holding top ice cube down to water level	What information does your diagram record this time?	What information is contained in the diagram now? What does the girl's diagram tell you about changes in water level?	5 Process Communicating

Discussion Period and Time	TV Image	SFTS/ITV: INVESTIGATING ICE AND WATER		Teaching Strategy
		Final Broadcast Statement	Suggested Statements or Questions	
7 60 sec.	The three diagrams	Take a moment to look over the the diagrams and see if you can predict how much space will be taken up.	Where do you think the water level will be when the ice melts?	5 Process Predicting

Title: Investigating Ice and Water (Dorothy Alfke)

Level: Intermediate

Aims: From SFTS Toward Which This Lesson Contributes

1. The students will solve problems by gathering information, working independently (individually or in small groups), using equipment and materials, observing purposefully and drawing appropriate conclusions based on these findings.

2. The students will demonstrate competency in the use of the processes in science by (a) observing, (b) communicating, (c) measuring, (d) inferring, (e) formulating hypotheses, (f) interpreting data, (g) controlling variables, and (h) experimenting.

3. The students will construct quantitative and qualitative records that can be used for reaching tentative conclusions.

4. The students will accept and modify ideas, and defend a point of view by making use of supporting evidence.

5. The students will explain basic conceptual schemes of the material world using personal experiences acquired through various activities as the basis for explanations.

Instructional Objectives: At the conclusion of this lesson the students will:

1. Interpret information provided by a simple diagram.

2. Communicate an idea by use of a simple diagram.

3. State a relationship between the volume of a piece of ice and the volume of water it changes to and/or is formed from.

Background Information:

A main focus of this lesson is communication by diagrams. Both interpreting and drawing diagrams are skills which are assumed but rarely taught.

Several aspects of diagrammatic representation are developed through this lesson:

1. Diagrams are simple representations rather than realistic drawings, i.e.: a glass can be represented . We often cannot tell any more information by trying to develop a three dimensional representation such as . In fact, we make our message more confusing.

2. We transmit information through diagrams, therefore, we must be careful to show clearly the ideas we want to communicate. In this lesson, our diagrams must show changes in water level.

3. Diagrams can save us many words. Time during the lesson can profitably be spent helping children appreciate how many words or statements the diagram replaces.

The other component of this lesson is the volume relationship between ice and the water it forms and vice versa. This is not an easy concept for intermediate grade children to comprehend. Experience suggests that they develop some interesting inferences or explanations for their observations. Do not force the children to accept verbalizations. Allow the children to evolve their own ideas, using your discussion leadership to help them achieve a fit between observations and inferences. This experience with volume changes associated with

water $\rightleftharpoons$ ice is a good readiness experience for study of density in later grades.

Ice to water - volume decreases

Water to ice - volume increases

The water level after the ice melts should be the same as the water level when the ice is floating freely in it. However, intermediate level children should only be expected to grasp the idea that when ice changes to water it takes up less space than it did as ice. Some intermediate level children are not ready to formulate even this relationship and should not be forced to do so.

This lesson offers an excellent opportunity to help children grow in their concept of the term volume. The teacher is encouraged to interchange the word "volume" with the phrase "amount of space it takes up" during class discussion.

Total Equipment List for a Class of 30:

Diagram Record Sheets (30 and spares) (a sample is included in this lesson)

30 Icicle Problem Sheets (a sample is included in this lesson)

Food coloring

For each group of four or five children:

A tall, straight-sided glass or jar with a rubber band near the top

Water (cold)

2 plastic forks or other devices to submerge the ice cube

A lid for the glass or jar (does not have to fit snugly)

Colored pencils or crayons (if desired for diagrams)

About 9 ice cubes

Activity 1 - Readiness Activity

Materials needed -

Diagram Record Sheets (30 and spares)

Food coloring

For each group of four or five students:

A tall, straight-sided jar with rubber band near top

Cold water

2 plastic forks

Lid for jar

About 9 ice cubes

Colored pencil or crayon

Distribute a glass and fork to each group and a diagram record sheet to each child.

Through discussion, help the class to recognize that the drawings are diagrammatic representations of a side view of the glass. Explain that they will be using these pages to make a record of their investigation by adding more information to the diagrams.

Have the children pour water in the glass so that it is about one-third full and add a drop of food coloring. Tell them to record what they have done by indicating the water level in part one of the diagram record sheet.

Place the ice cubes in the container. Add as many as will freely float in the water without touching the bottom. Instruct them to hold the ice cubes below the surface of the water with the help of

the fork and use the rubber band to mark the level of the water plus the submerged ice cubes. Stress the importance of accuracy and make it clear that once the rubber band marks the level of water plus ice, it must not be moved. Circulate to help and to encourage the children to discuss their ideas about the difference in water level while the ice is submerged and when the ice is freely floating.

Have the children use parts 2 and 3 of their diagram record page to show how the jar, rubber band, and contents look when ice cubes are submerged and when they are floating. Help the children to use simple diagrams. Ask questions to lead the children to explain or change any representation which seems inappropriate. Stress the importance of an eye level view in determining water level.

When the children have completed their diagram records through part 3 on the diagram record sheet, ask them to think about how the jars might look when all the ice has melted. Focus their thinking on the water level. Tell them to write their prediction about the water level in the space provided, stating their choice or "even with the rubber band," "higher than the rubber band," or "below the rubber band." After all have written their predictions, discuss their ideas which led to their predictions. Do not show favor for any choice.

Label the glasses for group identification. Distribute a lid for each glass and discuss the reason for using a lid (to prevent evaporation if the glasses are left for a period of time). Place the glasses where they will not be disturbed.

Activity 2:

Materials needed -

Those from Activity 1

Later in the day or on the following day, when all the ice has melted, group the children as in Activity 1 with their own glasses. Have them observe and record their observations concerning the height of the water in the container on the record diagram sheet in the space below their prediction and on part 4 of the diagram.

Encourage discussion of their observation.

1. If all results are not consistent, lead the children to identify a need to repeat the activity. Discuss possible differences in procedure among the groups that might have contributed to differences in outcome. Help the children to avoid such variables.

2. When consistent results have been obtained, ask the children, "Which takes up more space, ice or the water from which it is formed?" Discuss this question only to the extent that the interest and ability of the class seems to indicate. The concept involved in this question is not a basic lesson objective.

Activity 3:

Materials needed -

Paper cups

Water

Freezer or an outside location if the outdoor temperature is below freezing (access to below freezing temperature)

This can be done in school or at home.

Have the children put water in a paper cup (about 3/4 full), marking the level in any way they choose. Then place the cups in a freezer, or outdoors if the temperature is below freezing, until the water has frozen solid.

Discuss the results, relating the discussion to question number 2 of Activity 2 and to the observations in Activities 1 and 2.

Activity 4 - Competency

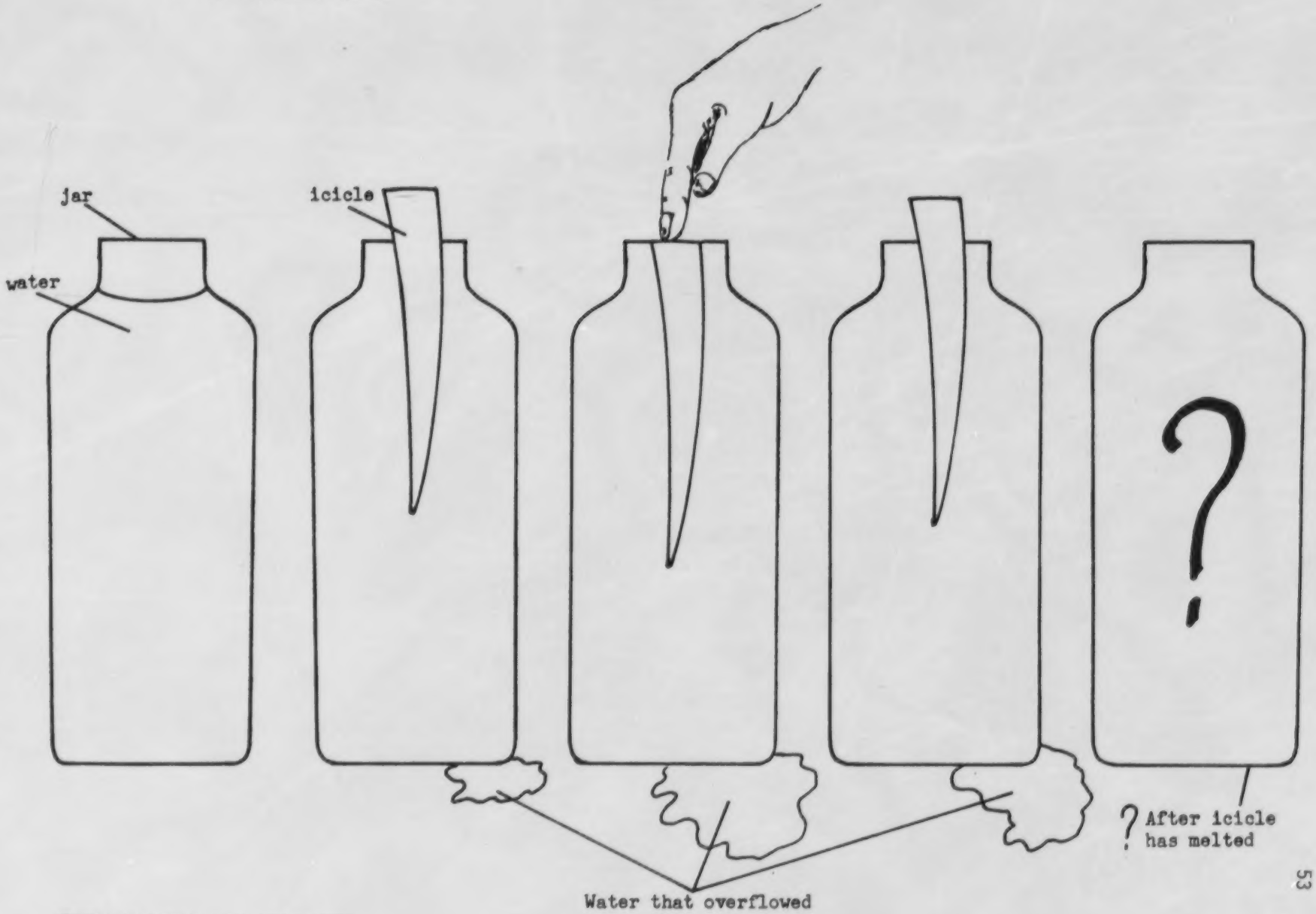
Materials needed -

Icicle Problem Sheets (1 per pupil)

Distribute the drawings of the icicle problem. Through class discussion, have the children in the class interpret the information provided by the first four diagrams.

Have them complete the last diagram to show their prediction of how it will look when all the icicle has melted. When all the children have done this, discuss their ideas, encouraging them to relate their reasoning to evidence obtained in Activities 1, 2, and 3.

ICICLE PROBLEM SHEET



INVESTIGATING ICE AND WATER

INVESTIGATING THINGS THAT MAGNIFY

Television Introduction

Teacher Orientation

This introduction is designed to provide a transition into the "science activities" which you will conduct following it. You will probably want to spread the SFTS lesson activities over several days. Emphasis in this television presentation will be placed upon introducing basic concepts and techniques leading to student instructional objectives as well as techniques that you may use to promote these desired objectives.

This television program uses very simple production techniques to lead students to identify all characteristics of several magnifiers and then narrow these down to the characteristics that are essential for a magnifier. This will lead to further investigation during the SFTS lesson as well as the location and preparation of additional magnifiers.

Early in the televised program, a young child has need for a magnifier to examine and sketch insects. Thereafter, four different types of magnifiers are shown. During the televised program, your pupils are expected to list the characteristics of each on a chart like the one below.

In preparation for the television program it is important that you have the following chart on the chalkboard or on an overhead transparency so that you can fill in the characteristics of various lenses as they are discussed.

Characteristics of Magnifiers			
First Magnifier	Second Magnifier	Third Magnifier	Fourth Magnifier

Discussion Period and Time	TV Image	SFTS/ITV: INVESTIGATING THINGS THAT MAGNIFY (20 min.-color)		Teaching Strategy
		Final Broadcast Statement	Suggested Statements or Questions	
1 2 min.	Round magnifying glass	Suppose you list as many characteristics as you possibly can.	What are all the characteristics that you can identify about this magnifier?	2 Ans. ^ Evidence
2 1 min.	Round magnifying glass	Go over your list, as you look at the magnifier again, and see if you can pick out what you consider to be essential characteristics.	Of all of the characteristics that you have listed, which do you think are essential for it to be a magnifier?	3 Approval
3 1 1/2 min.	Plastic magnifier	Take a minute and list all the characteristics of the magnifier.	What characteristics can you identify in this magnifier? List them in the second column on your chart.	5 Process Observing Communicating
4 1 1/2 min.	Rectangular magnifying glass	Now let's examine another one and make still another list of characteristics.	Let's list all of the characteristics that you can see here in the third column of the chart.	4 Wait time
5 1 1/2 min.	Round lens	And finally, list all the characteristics of this magnifier.	Again, what characteristics do you see? List them in the fourth column.	2 Ans. ^ Evidence
6 2 min.	Four magnifiers	You may want to recheck or reword some of the characteristics as you discuss them.	Which of the characteristics that you have listed do you think are essential for all magnifiers?	5 Process Classifying

Discussion Period and Time	TV Image	SFTS/ITV: INVESTIGATING THINGS THAT MAGNIFY		Teaching Strategy
		Final Broadcast Statement	Suggested Statements or Questions	
7 3 min.	Examples of magnifiers in use	Let's look at some devices which have magnifiers in them. While we do, discuss what these devices are and what they are used for.	Let's check each of these magnifiers against our list of essential characteristics Does it appear that each one has the essential characteristics of a magnifier?	3 Approval

Title: Investigating Things that Magnify (Dorothy Alfke)

Level: Intermediate

Aims: From SFTS Toward Which This Lesson Contributes

1. The students will solve problems by gathering information, working independently (individually or in small groups), using equipment and materials, observing purposefully and drawing appropriate conclusions based on these findings.

2. The students will construct qualitative records that can be used for reaching tentative conclusions.

3. The students will identify examples of scientific hypotheses and theories as evidence that our interpretation of truth changes as knowledge increases.

Instructional Objectives: At the conclusion of this lesson, the students will:

1. State at least two characteristics which are common to most magnifiers.

2. Predict whether an object will function as a magnifier by identifying at least three characteristics which are similar to magnifiers which they have investigated during lesson activities.

3. Decide, when they encounter a magnifying object not previously used, whether changes are needed in their list of characteristics common to magnifiers.

Background Information:

In this lesson, the students proceed through a sequence of activities in which they narrow down a list of observable characteristics

of hand lenses to those characteristics common to a more varied assortment of magnifiers with which they work. In this process they eliminate many characteristics which are not essential for achieving magnification, (i.e., has a handle, is round, is made of glass).

This lesson helps children gain skill in identifying relevant and eliminating irrelevant information which may interfere with productive investigation.

The wording of the statements on the list should be determined by the children. They will probably want to refine these statements as they work with the list throughout the lesson.

The final list might include statements such as:

thicker in the middle than at the edges

the surfaces must be smooth

can be seen through

solid or filled with water

During the course of the lesson, a child might bring in a magnifying mirror. It should, of course, be investigated by the class. However, since this is a reflection type magnifier, the teacher is advised to suggest that the class limits its consideration in this lesson to lens (refraction type) magnifiers.

The pennies used in the first activity should be checked beforehand to be sure that the statue of Lincoln in the Lincoln Monument shows under the hand lens.

Usually children can bring magnifying lenses from home. This will help to supplement school resources and provide variety.

Some children will comment on their observation that some objects make things smaller rather than larger, (i.e., bottles of water with air bubbles or transparent objects which are thinner in the middle than at the edges). The teacher should accept any such observation with enthusiasm. Inferred cause and effect relationships can be identified. The decision whether to pursue this to a generalization will depend upon student interest and ability.

Total Equipment List for a Class of 30 Pupils:

30 pennies with Lincoln statue visible on reverse side

15 or more hand lenses, preferably assorted

30 pieces of thin clear plastic, about 1" x 2" or
30 glass microscope slides

6 to 8 cups or jars of water

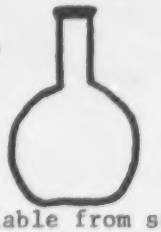
(6 to 8 medicine droppers, if available)

60+ pieces of print cut from newspapers or magazines -
approximately 2" x 2"

at least 20 assorted objects for investigation for potential magnifiers (see suggestions below)

capped plastic pill bottles:
- some empty
- some filled with clear water
- some filled with faintly colored water
- some filled with intensely colored water

capped bottles with evenly "bulged" sides
with and without water



capped bottles with flat sides

watch glasses and lens sets (may be available from science department in high school)

eyeglasses

medicine droppers

clear plastic or glass tubes

transparent plastic handles (brushes, etc.)

(try to obtain a collection of some objects which do a good job of magnifying and others which have some, but not all, of the characteristics of magnifiers)

Activity 1 - Readiness Activity

Materials needed -

a penny for each student

hand lenses - one for each student or pair of students, if possible; assorted, if possible

Distribute the pennies and hand lenses. Tell the children to discover as many things about the penny as they can with the help of the lens.

Ask the children to identify and make their own list of the characteristics of the magnifiers they are using, (e.g., the lenses are clear, etc.). If necessary, clarify the meaning of the term characteristic.

After allowing time for the children to develop lists of several characteristics, have each child, in turn, read an item from his or her list. Guide class discussion of any items which seem to need clarification.

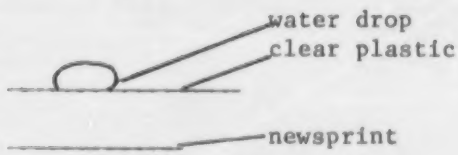
Ask the question, "Which of the characteristics that we have identified are common to all of our magnifiers?" List on the chalkboard

any characteristics which the class agrees upon. Have the children record this list to use later.

Activity 2:

For each child - a piece of plastic

a piece of newsprint



For each group of four students - a small container of water

a medicine dropper or other drop maker

Demonstrate how to place a drop of water on the clear plastic piece (see drawing) and then tell the children to make their own water drop magnifier and use it to look at the newsprint. As you circulate, encourage the children to investigate further by varying the size and shape of the drop, and by turning the plastic piece over so that they have a hanging drop.

When the class has had enough time to use the water drop magnifiers, guide the children through a re-examination of the list of common characteristics, removing or adding any items which seem to be justified by this new experience with magnifiers.

Activity 3 - Competency

Materials needed -

an assortment of at least 15 different objects to be investigated to see if they can be used as magnifiers (see total equipment list)

for each child - a piece of newsprint

Have children work in small groups of two to four children. Give each group one of the objects. Explain that the children are to find out if their object can be used as a magnifier. When they have investigated the object, they are to re-examine their list of common characteristics and decide if any changes need to be made on the list. When they have done this, they can exchange their object for a new one. (NOTE: This activity is well suited for a learning center.)

Conduct a class discussion of modifications of the list justified by this activity.

Extending Activities:

1. Add to the assortment of objects used in Activity 3 some bottles and/or other suitable objects which are thinner in the middle than at the edges. Encourage children to identify characteristics of "objects that make things look smaller."
2. Suggest that the children try to find as many uses of magnifiers as they can. Some children might make a bulletin board display.
3. If possible for the children to do so, suggest that they examine the lenses in cameras, eyeglasses, microscopes, telescopes or other objects which have lenses. Suggest that they find out what they can about how the lenses differ in appearance and in magnifying power.

INVESTIGATING FRICTION

Television Introduction

Teacher Orientation

This introduction is designed to provide a transition into the "science activities" which you will conduct following it. You will probably want to spread the SFTS lesson activities over several days. Emphasis in this television presentation will be placed upon introducing basic concepts and techniques leading to student instructional objectives as well as techniques that you may use to promote these desired objectives.

In this case, the major emphasis of the television program will be placed upon assisting your students in the construction of the friction apparatus (shown in Figures 1 and 2 of the SFTS lesson, "Investigating Friction") which is used in a number of the activities of the SFTS lesson that you will conduct following the television program.

This televised lesson does not have the conventional discussion periods typical of other SFTS programs. However, early in the television program, a young boy recalls examples of friction. These examples extend over about two minutes and fifteen seconds. During this time, discuss these scenes with your students using teaching strategies 2 and 3. During the major portion of the televised lesson, the construction of the friction apparatus is demonstrated. Then, the friction device is pulled across a number of surfaces. This provides an opportunity to conduct another discussion period. Strategy 5 (inferring) would be useful at this point.

To prepare for the television program, it is <u>important</u> to have students properly arranged and supplied to construct the apparatus used in the SFTS lesson. Students should be arranged with two to four in a group. On a table or desk <u>for each group</u>, the following <u>materials should be provided</u>:

1 chalkboard eraser
1 18 inch piece of string
1 paper clip
1 thin, flexible rubberband
1 12 inch ruler
1 pair of scissors
1 pencil
1 roll of masking tape (about 12 inches will be needed)
1 piece of heavy cardboard about 1 inch wide and 11 inches long

Prepare the groups of students in advance to be ready to work together to assemble a piece of apparatus as its assembly is demonstrated during the television program.

During the televised program, the young boy assembles the measuring device described in the lesson. He works from a blackboard outline showing each step. This outline is shown on the following page to assist you.

SCIENCE CENTER

Investigating Friction

Where have you seen friction occur?

Assemble the Friction apparatus

Hook clip to string

String

Rubberband

Paperclip

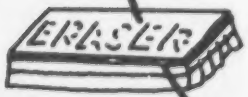
Mark on rubberband

Test Surfaces and Record Data

What Did You Discover ?

Gauge

Tape Gauge to eraser



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Title: Investigating Friction (Roy Allison and Duane Smith)

Level: Intermediate

Aims: From SFTS Toward Which This Lesson Contributes

1. The students will solve problems by gathering information, working independently, using equipment and materials, observing purposefully, and drawing appropriate conclusions based on these findings.

2. The students will explain basic conceptual schemes of the material world using personal experiences acquired through various activities as the basis for explanation.

3. The students will demonstrate a competency in the use of the processes of science by: (a) observing, (b) classifying, (c) communicating, (d) measuring, (e) controlling variables, (f) experimenting, (g) recording, (h) predicting, and (i) interpreting data.

Instructional Objectives: At the conclusion of this lesson, the students will:

1. Order surfaces from rough to smooth.

2. Measure the force required to pull an object over a given surface.

3. Describe the relationship of the amount of force required to move the object to the relative roughness of the surface.

4. Predict the order of roughness of objects given the force required to pull an object over them.

5. Predict the relative force required to pull an object across three surfaces given the order of surface from rough to smooth.

6. Describe the relationship of the amount of force required to move the object over a surface to the amount of weight on the object.

7. Predict the relative weight on an object given the force required to pull the object over a surface.

8. Predict the relative force required to pull an object across a surface given the order of load on the object from light to heavy.

Background Information:

Force has traditionally been defined as a push or a pull. Any push or pull is usually defined as a force. This is an example of a circular definition. The activities in this lesson provide students with experience in working with forces rather than the verbalization of this circular definition.

It is advantageous to permit the students to develop a concept of what a force is rather than just to talk or to read about "force." Experimenting with forces through the investigation of friction is an excellent approach.

In this lesson we will use unbalanced forces which produce motion (forces in equilibrium do not produce motion). The forces in these activities will be sufficient to produce motion. In all of these activities we will be using the pull on a rubber band to produce the

unbalanced force (see Figure 1). The magnitude of the unbalanced force needed to produce and sustain uniform motion will be read from a simple scale which indicates how far the rubber band is stretched (described in Activity 2). Students will need practice pulling objects with the rubber band. Permit them as many tries as is necessary for them to produce sustained uniform motion. The amount of practice may vary from one student to the next, but each should be able to master this technique with practice.

Figure 1

Ask the students to observe the relative lengths (amount the rubber band is stretched) from the time they begin to pull until their object begins to move. It takes a greater force to get the object moving (to overcome stationary inertia) than to keep the object in motion (to overcome friction) once it has started.

After successive trials, the students should be able to summarize in their own words observations such as the following:

1. The rubber band stretches a long way (longest) before the object begins to move.
2. The object usually begins to move with a jerk or start.

3. Once the object starts to move, the rubber band is not stretched quite as far.

4. It takes practice to have the object move at a uniform rate.

The students, at this point, will have discovered important scientific concepts. The activities which follow in investigating friction will sharpen and clarify these concepts.

Total Equipment List for Each Group:

1. Rough paper (such as a teacher's desk blotter or construction paper)
2. Piece of smooth plastic (overhead transparency film or equivalent)
3. Rough sandpaper (coarse)
4. Fine sandpaper
5. Smooth board
6. Rough board
7. Chalkboard eraser
8. String
9. Rubber bands (thin ones work best)
10. Block of wood approximately 8 cm x 13 cm, any thickness, or any item of similar size to which a rubber band may be attached can be substitued.
11. Several hexagonal pencils
12. Several round pencils or dowels

13. A child's small plastic car or truck capable of carrying the block of wood or similar item in No. 10 of list
14. A popsicle stick
15. Other objects or surfaces chosen by the group
16. Clay for adding weight
17. Screw eye
18. Paper clips

Activity 1 - Ordering Surfaces

Materials needed for each group:

Teacher's desk blotter or construction paper

Piece of smooth plastic (overhead transparency film or equivalent)

Piece of sandpaper (rough or coarse)

Piece of fine sandpaper

Smooth board

Rough board

The object of this activity is to give the pupils an opportunity to feel the surfaces of the various materials, and to have them order the materials from the smoothest to the roughest. The teacher may introduce this activity by using two objects which are far apart on the rank order scale for surfaces, such as the coarse sandpaper and the smooth board. Allow the children to rub their fingers across the surface of both objects and have them describe the two surfaces in their own words. As they become more adept at distinguishing between smooth and

rough surfaces, introduce additional materials for them to investigate. Have the children order all surfaces from smoothest to roughest.

Activity 2 - Friction Related to Surfaces

Materials needed for each group:

Teacher's desk blotter or construction paper

A smooth-topped table

Chalkboard eraser

String

Rubber bands

Clay (for adding weight)

Paper clips

A chalkboard eraser is the object to be pulled over each of the surfaces. Each group of students will prepare a chalkboard eraser and rubber band pull as shown in Figure 1. The directions are as follows:

Tie a string around the edges of the chalkboard eraser. Cut the rubber band to form a single strand. Tie one end of the rubber band to the end of a paper clip. Hook the paper clip over the string in the center of one end of the eraser.

It may be necessary to add sufficient weight to the top of the eraser (a piece of clay works well) to keep it sliding on surfaces to be tested and to avoid having the eraser jump or hop across the surfaces.

Stress that the children should observe the length of the rubber band when the object is undergoing smooth, uniform motion, and not at the time motion first begins. The teacher should initiate this

activity with one of the rough surfaces and one of the very smooth surfaces. The two surfaces should produce an obvious difference in the length to which the rubber band is stretched.

The teacher should guide class discussion to help the students establish a means of measuring the unbalanced force. Students will probably suggest holding a ruler beside the eraser and measuring the length of the rubber band for each trial. The students should be encouraged to test their suggestions and to devise a system which works consistently. A scale attached to the eraser will work well since it moves with the eraser. A piece of cardboard or heavy paper folded and attached as in Figure 2 below, is an example.

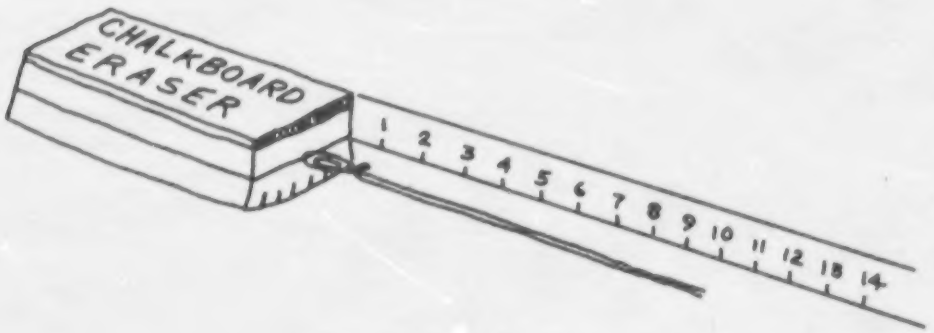


Figure 2

The only difference between Figure 1 and Figure 2 is the addition of the scale.

The sample scale used in the trial lessons was a 3 cm x 29+ cm (1" x 12") strip cut from a file folder, folded in half lengthwise, marked with a scale of 1 cm spaces (or 1/4"), and attached to the felt

chalkboard eraser with staples. (Foam erasers with plastic hand grips require tape to hold the scale in place.)

A single strand of a thin rubber band works best for this activity. Run several trials on each surface being investigated. The students should record the scale reading for each trial. The students should be encouraged to grasp the rubber band at the same place every time so that the scale readings will be consistent.

Students should be encouraged to suggest other surfaces to be tested. It is recommended that these materials be made available to them for free time experimentation at their desks or a learning center. The students should be encouraged to compare the readings on one type surface with the readings on other types of surfaces. In general, the readings will be higher on rougher surfaces.

Activity 3 - Reducing the Effect of Friction

Materials needed for each group:

A smooth block of wood (8 cm x 13 cm, any thickness) with a screw eye at one end or any item of similar size to which a rubber band may be attached

Several hexagonal (six-sided) pencils

Several round pencils or dowels

A child's small plastic car or truck capable of carrying the wood block or similar item

The rubber band indicator from Activity 2 or a similar measuring instrument

In this activity the students will distinguish between the forces necessary to overcome the friction of sliding and rolling objects. The students should record the length that the rubber band is extended as an indication of the relative amount of force required to move the object. The teacher is cautioned once more to have the children observe the length to which the rubber band is stretched when the object is in smooth, uniform motion. The students may have to practice to be able to sustain uniform motion under these new conditions.

The teacher may wish to initiate this activity by repeating a portion of the previous activity to reinforce the fact that a greater force is required to slide an object over a rough surface. It will be necessary to grasp the rubber band at the same place at all times during this activity if one set of readings is to be compared with another.

The hexagonal pencils are placed under the wood block or similar item as rough rollers. The amount of force required to move the block with these rollers is then compared to the force required to move the block without the rollers on the same surface. Repeat this activity using the round rollers. Compare the amount of force required to move the block with the hexagonal rollers.

Place the wooden block or similar item on the plastic car or truck. Compare the amount of force required in this instance to the amount of force required to move the block when using the round rollers. It may be necessary to experiment with the thickness of the rubber band in order to produce an observable force difference. The same rubber band should be used throughout the activity.

Activity 4 - Friction Related to Weight

Materials needed for each group:

A smooth block of wood (8 cm x 13 cm, any thickness) with a screw eye at one end, or similar item to which the rubber band can be attached

Clay

The rubber band indicator

In this activity, students establish the relationship between the weight of an object and the force necessary to overcome the friction between that object and the surface over which it moves.

The teacher may wish to initiate this activity by repeating a portion of the previous activity where a wood block or similar item was drawn over a surface. Once the force required has been re-established and recorded, the teacher should then place some additional weight (clay) on the block and ask the students to predict whether or not additional force would be required to move the block. The students then experiment to verify their predictions. Students can be asked to predict the effect of adding more weight to the block. It would be desirable to have the students record the force needed to move the block. The recorded forces can then be compared.

Activity 5 - Competency Measure

Materials needed for each group:

Blocks of wood (8cm x 13 cm, any thickness) with a screw eye at one end, or similar item to which the rubber band can be attached

Clay

Rubber band indicator

In this activity the teacher should give each group of students materials with surfaces the students have not tested. Have each group pull the blocks of wood over the new surfaces and record the force needed for each surface. Have them place the surfaces in order from smoothest to roughest using the data just taken. Have the students check this order by feeling each surface. Ask the students to demonstrate how the weight of a block affects the force required to pull the block.

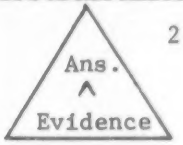
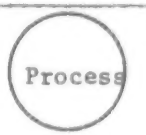
INVESTIGATING PROBLEMS OF SPROUTING SEEDS

Television Introduction

Teacher Orientation

This introduction is designed to provide a transition into the "science activities" which you will conduct following it. You will probably want to spread the SFTS lesson activities over several days. Emphasis in this television presentation will be placed upon introducing basic concepts and techniques leading to student instructional objectives as well as techniques that you may use to promote these desired objectives.

A strong effort is made to alert the viewer to adverse conditions under which seeds are able to sprout and plants grow. Then, through time-lapse photography, these processes are shown and the movement of the plant upward through the soil is witnessed. Opportunities are provided to discuss what is seen and compare the variety of ways in which different plants move up through the soil. Students are encouraged to make inferences about how some characteristics which they notice in each sprouting seed might help the seedling succeed in spite of problems in their environment.

Discussion Period and Time	TV Image	SFTS/ITV: INVESTIGATING PROBLEMS OF SPROUTING SEEDS		Teaching Strategy
		Final Broadcast Statement	Suggested Statements or Questions	
1 1 1/2 min.	Examples of ways that seeds travel	What special ways for traveling do these seeds have?	What can you tell about how these seeds travel?	 2
2 1 min.	Seed traveling	What ideas do you have about the importance of traveling seeds?	What might be advantages of seeds landing away from the plant they came from? What problems might result from seeds traveling?	5 Inferring
3 2 min.	Time lapse photography of sprouting bean	What do you notice about the shape of the young plant?	Does the shape of the sprouting seed seem to relate in any way to its movement through the soil?	5 Observing
4 2 min.	Time lapse photography of sprouting bean	Do you notice any difference in the way it sprouts and grows?	Is this sprout any different from the other one?	5 Communicating
5 2 min.	Time lapse photography of sprouting corn	What characteristics do you notice about its shape?	What are some characteristics of this different type of sprouting seed?	3
6 2 min.	Time lapse photography of corn and bean (split screen)	What ideas do you have about how the characteristics of each of these might help the tender young plant push through the soil?	How might some of the things you notice help the tiny plant work its way to the surface?	 5 Inferring

Discussion Period and Time	TV Image	SFTS/ITV: INVESTIGATING PROBLEMS OF SPROUTING SEEDS		Teaching Strategy
		Final Broadcast Statement	Suggested Statements or Questions	
7 2 min.	Bean seeds planted under rocks of various sizes	What other problems of sprouting seeds might be interesting for you to investigate?	Think of places in gardens or around our school building where certain conditions are not ideal for seeds to succeed in sprouting.	4 Wait Time

Title: Investigating Problems of Sprouting Seeds (Dorothy Alfke)

Level: Intermediate

Aims: From SFTS Toward Which This Lesson Contributes

1. The students will formulate and ask questions of their environment as part of their efforts to describe, clarify, analyze problems, and provide direction for problem solving.
2. The students will accept and modify ideas, and defend a point of view by making use of supporting evidence.
3. The students will demonstrate a desire to learn and a curiosity for the unknown by formulating and performing self-motivated investigations.
4. The students will explain basic conceptual schemes of the material world using personal experiences acquired through various activities as the basis for their explanation.
5. The students will identify examples of scientific hypotheses and theories as evidence that people's interpretations of the truth change as their knowledge increases.

Instructional Objectives: At the conclusion of this lesson, the students will:

1. Identify several types of seedling structures (adaptations) which help the seeds in getting through the soil.
2. State at least two practices which would increase success in growing plants from seeds.

Background Information:

Seeds often suceed in sprouting under quite difficult conditions.

One can identify or infer some interesting structures (adaptations) in some sprouting seeds which enable them to exert a surprising amount of force against obstacles which impede their growth. Some sprouting seeds demonstrate adaptations which protect the tender shoots against the abrasive friction of soil or obstacles in the soil.

This lesson is, in part, designed to foster a sense of wonder in children, to encourage them to raise questions as they make observations, and to give them experience in making inferences based upon their observations.

Examples of inferred adaptations for success in germination include:

1. Corn, grasses and related plants emerge from the ground with the tender young leaves rolled into an overlapping tubular pattern which is quite pointed at the tip. The pointed tip helps pierce an opening through the soil. The coiled overlap gives more strength and rigidity to the leaves than they would have if they pushed out in an open position. An analogy for children can be demonstrated by having them push an open sheet of paper against an obstacle and compare its force with that of the same sheet of paper rolled into a tube and used to push the same obstacle.
2. Squash, pumpkin and cucumber seedlings push their seedcoat ahead of them. This fairly rigid, streamlined protection would seem to help the seedling push through the soil and help prevent damage to the tender young leaves.

3. The arch pattern emergence of the stem of the bean usually pushes ahead of the leaves, helping to break a path through the soil for the rest of the plant top to push through.

It is important that teachers do not restrict inferences to those discussed above. Children should be encouraged to generate and communicate their own ideas about factors which might enable seeds to sprout in spite of difficulties in their path.

This lesson also deals with soil compaction (how tightly packed the soil is), the effect of the depth of planting, and other factors which are related to the success or failure of seeds to germinate and sprout.

Little is found in popular books about seed germination and sprouting problems. However, children can usually find some good references on the structure of seeds and on good gardening practices for growing plants from seeds.

Total Equipment List for a Class of 30:

Eight flower pots or other suitable containers
Soil (sufficient for the eight pots)
At least 30 of each of 3 or 4 kinds of seeds
- squash or pumpkin
- corn (sweet corn, indian corn, or field corn)
- beans - any kind
- radish, beets, nasturtium (or whatever is available)

Additional materials as needed for Activity 4
Large flower pot and soil for teacher's use.

Activity 1 - Readiness

Materials needed for each student - notebook and pencil (optional)

Take the class on a field trip to observe and discuss examples of young plants which have been able to sprout and grow under difficult conditions, such as hard packed soil, or by growing through cracks in sidewalks, rocks, or cement. Guide the discussion to raise questions in the children's minds about responses of seeds to adverse sprouting conditions. Such discussions would also survey the children's background on conditions essential or favorable to seed sprouting. Keep a record of their observations.

School grounds are usually well suited to such a field trip. A group can usually find many examples of seedlings or young plants which have succeeded in sprouting and even surviving under seemingly adverse conditions.

Activity 2:

Materials needed for each group of about 4 students:

Flower pot, milk carton or suitable alternative
(with holes in bottom for drainage)

Soil

Two or three seeds of each of three or four different kinds (Suggestions: squash or pumpkin, corn, peas, beans, radishes, beets, grass)

Through class discussion, establish the purpose of the activity as attempting to derive information about the differences in the ability of various kinds of seeds to overcome problems of sprouting through

tightly packed soil. Some group(s) of children will not compact the soil in which their seeds are planted, some will compact lightly, some moderately and others will make the soil in which their seeds were planted strongly compacted. Relate this discussion to observations made in Activity I and to conditions found in gardens, lawns, and areas where soil gets packed down by foot traffic or other means.

Establish a procedure for planting the seeds and for compacting the soil. Decide how the range of soil compaction will be achieved among the groups.

Distribute the materials and circulate among the groups to help as needed. Some children will probably ask questions, such as "How deep should we plant the seeds?" and "Does it matter which part of the seed points down?" Since such questions can be answered by pupil investigation, you might suggest that they work out a way to answer such questions by experimenting.

When the planting and compacting has been completed, have the class establish a workable plan for locating and caring for their planted seeds. During discussion, help the children plan so as to minimize such variables as temperature, light and water.

To assure the identification of the seedlings as they emerge, the teacher should also plant a set of two or more seeds of each type used and label this planted set. The children can then refer to these labelled sprouting plants to identify their seedlings as they emerge.

Activity 3:

As soon as growth appears at the surface of any of the pots, encourage the children to make observations of the variations in

characteristics of different kinds of emerging seedlings. Encourage the children to infer adaptations of different types of seedlings which help them push their way through the soil. Accept any reasonable inferences, encouraging children to wonder about and appreciate the general idea that plants demonstrate a great variety of adaptations for survival in the ways in which some tender shoots are enabled to work their way to the surface in spite of the kinds of problems associated with their environment.

Observation and discussion should, of course, also focus on differences in time of emergence of seedlings, noting variations according to compaction differences and according to kinds of seeds. It may also be relevant to raise a question about the variability of depth at which seeds had been planted.

Activity 4 - Competency Activity

Materials needed - as identified by investigation plan of each individual or group

Discuss with the children other kinds of problems which sprouting seeds might encounter. These might include periods of dryness, the weight of a board or rock, limited amount or absence of soil, poor quality of soil, darkness, competition with other seeds, or depth. The children can be expected to suggest additional problems.

Have individuals or small groups plan and carry out their own investigation to answer a question of interest to them, relevant to problems of germinating seeds.

Extending Activities:

1. Soak some dried lima beans and/or other bean seeds for about one day in water. Distribute two to each child and have the children carefully remove the seed cover and take the seed apart to identify the root and leaf enclosed within. The children might seek additional information from books about the function of other parts of the seed.
2. Encourage the children to examine other kinds of seeds, including those used as, or associated with, food (peanuts, orange and apple seeds, cucumber seeds, acorns or maple "pollynoses") to try to find the tiny plant structures within the seed.
3. Have the children try to get some of the seeds of the type examined in Number 2 to sprout.

INVESTIGATING HEAT LOSS

Television Introduction

Teacher Orientation

This introduction is designed to provide a transition into the "science activities" which you will conduct following it. You will probably want to spread the SFTS lesson activities over several days. Emphasis in this television presentation will be placed upon introducing basic concepts and techniques leading to student instructional objectives as well as techniques that you may use to promote these desired objectives.

Following a view and discussion of a number of ways in which energy is used, a diagram of a house and a home heating system are shown to illustrate heat loss in a home and ways in which insulation can cut down on this loss of heat. Several opportunities are provided for observation and discussion of what is shown on the television screen.

The following page contains charts and graphs which students fill out during the last 10 minutes of the television program. It is important that copies of the following page be made and distributed to members of the class before viewing the television program. If thermal duplication facilities are available, copies can be made inexpensively in that way. It is suggested that you may also wish to put these charts and graphs on a chalkboard, large chart, or overhead transparency for the entire class to see as you fill them out and work with them.

You will notice that the page following the empty chart and graphs provides approximate entries from the television program for your reference. It should be emphasized that if your students get slightly different readings from the thermometers shown on the screen, their judgments should be accepted and respected. In fact, they may be more accurate!

As always, the activities of the television program will provide useful background experiences for the lesson that follows.

INVESTIGATING HEAT LOSS

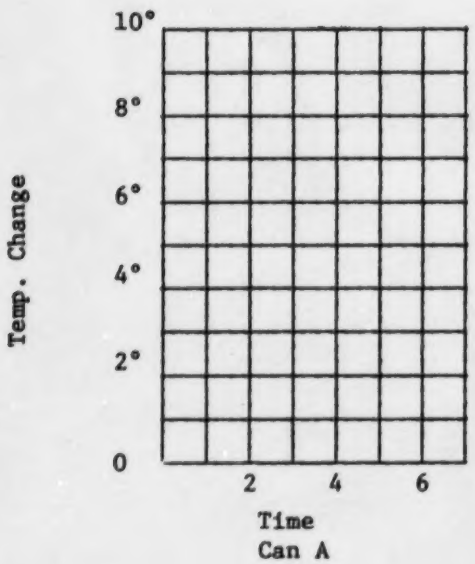
Charts and Graphs for Recording Data

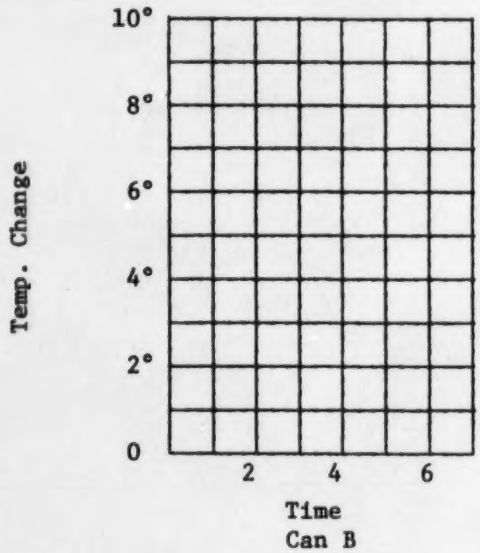
Time	Temp.	Temp. Change
0		
2		
4		
6		

Can A

Time	Temp.	Temp. Change
0		
2		
4		
6		

Can B





Thermal duplicate for classroom use during television program.

INVESTIGATING HEAT LOSS

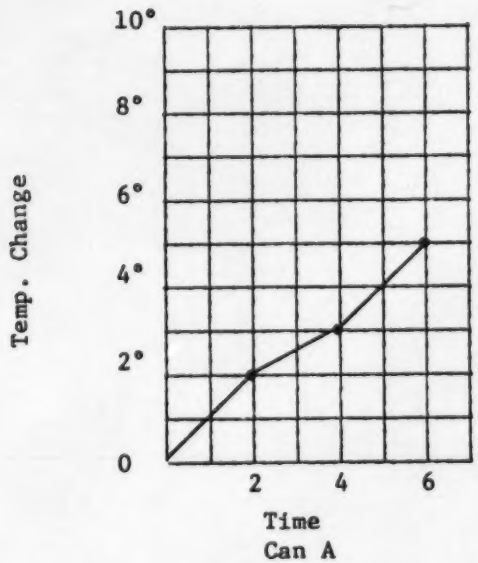
Approximate Data from Televised Experiment
(Teacher Information)

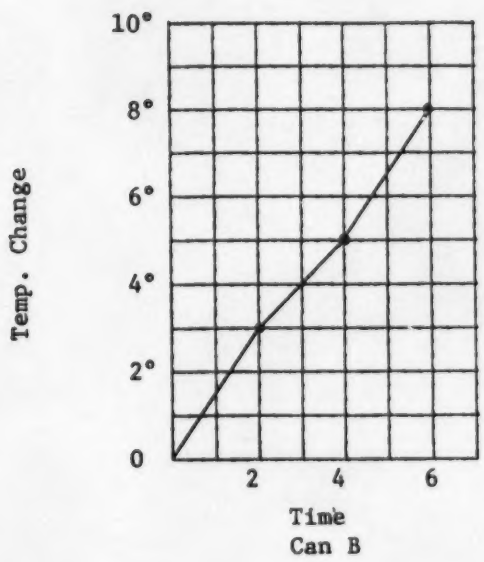
Time	Temp.	Temp. Change
0	120°	0
2	118°	2°
4	117°	3°
6	115°	5°

Can A

Time	Temp.	Temp. Change
0	120°	0
2	117°	3°
4	115°	5°
6	112°	8°

Can B





Discussion Period and Time	TV Image	SFTS/ITV: INVESTIGATING HEAT LOSS (20 min.-color)		Teaching Strategy
		Final Broadcast Statement	Suggested Statements or Questions	
1 1 min.	Scenes of examples of energy use	Watch closely and discuss the ways you see energy being used.	How is energy being used in each one of these examples?	2 Ans ^ Evidence
2 1 min.	Diagram of home and heating system	This diagram will help us to see how this home heating system works. What do you see happening?	Describe everything that you see happening.	3 Approval
3 30 sec.	Diagram of a home and heating system	Let's take another look at the home heating system now and discuss what you see happening.	What do you see happening?	5 Process Observing Communicating
4 15 sec.	Diagram of a home and heating system	Where else could we insulate to reduce heat loss?	Where would you put insulation in the house to cut down on heat loss?	5 Process Predicting
5 10 1/2 min.	Experiment being conducted	Watch every step of the experiment carefully. You won't want to miss any of the clues you need to understand the results of the experiment.	Watch carefully and record the data on your charts.	5 Process Measuring

Title: Investigating Heat Loss - Robert L. Shrigley

Level: Intermediate

Aims: From SFTS Toward Which This Lesson Contributes

1. The student will solve problems by gathering information, using equipment and materials, observing purposefully and drawing appropriate conclusions based on these findings.
2. The student will demonstrate competency in the use of processes of science by (a) observing, (b) measuring, (c) inferring, (d) interpreting data, (e) controlling variables, and (f) experimenting.
3. The student will construct quantitative records that can be used as evidence for reaching tentative conclusions.
4. The students will explain conceptual schemes of the material world using personal experiences acquired through various activities as the basis of their explanation.

Instructional Objectives: At the conclusion of this lesson, the student will be able to:

1. Read thermometers.
2. Plot temperatures on a line graph.
3. Suggest at least one material that might change the rate of heat loss when surrounding a small can of heated water.
4. Identify and list variables that must be controlled to test inferences concerning heat loss.
5. Design at least one experiment to test the effectiveness of an insulating material.

6. Predict at least one material not tested that might be more insulating, and one that might be less insulating than dead, non-moving air, and conduct to test the prediction.

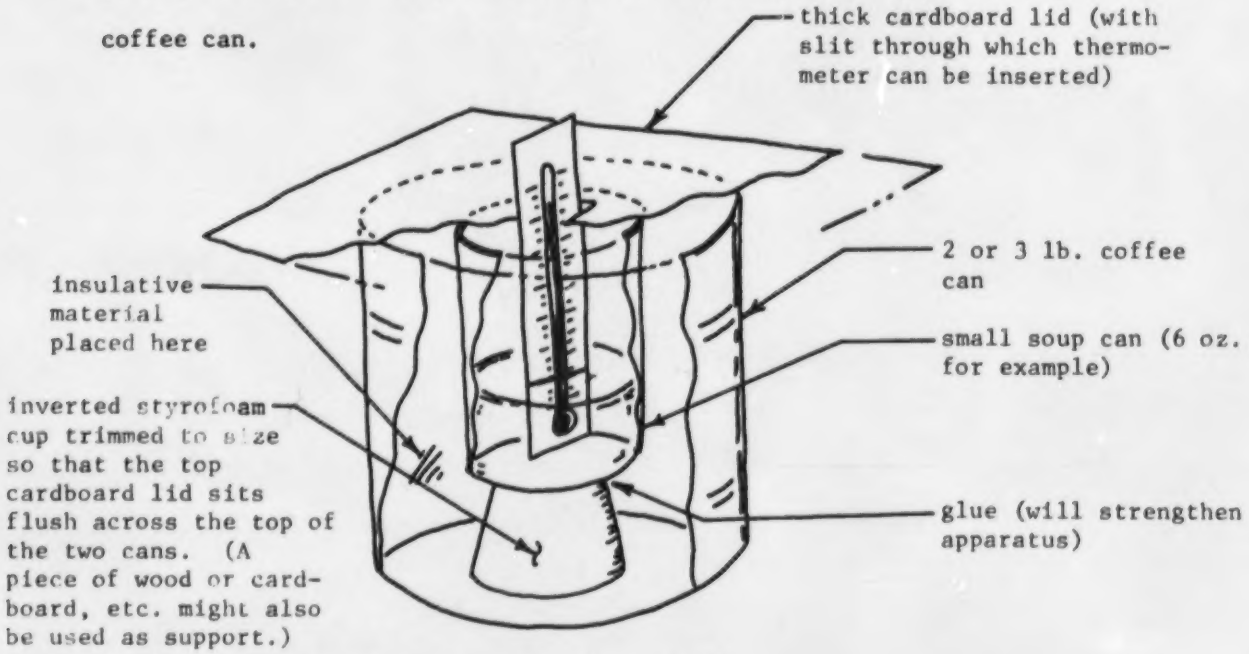
Background Information:

This lesson serves as a readiness activity for students embarking on a series of investigations concerning heat loss. In this case, the loss of heat is from warm water. Water heated to 50°C. (about 120°F.) is safe to handle and provides temperature changes which can be measured by an inexpensive thermometer. A thermometer with a metal or plastic base is preferred over a cardboard base thermometer.

Acquiring water at this temperature can best be done by placing the thermometer under the faucet as one slowly mixes hot and cold water until the temperature of approximately 50°C. is reached (a temperature high enough for noticeable heat loss in a short time). If you carry the warm water from home or the school lavatory, an insulative container for liquids (such as a thermos) is suggested to retard heat loss before the students use the water for their investigation.

Some students will need to practice their skills of reading a thermometer and graphing. A large cardboard thermometer with a moveable red ribbon simulating alcohol (See SFTS primary grade lesson, "Investigating Thermometers") would be an aid in this activity. A model thermometer outlined on a transparency and shown on the overhead projector would be a helpful aid. If (Celsius) thermometers are available, students should use metric measurements in this investigation.

Below is a simple apparatus that could serve as an insulation box useable by small groups to compare the insulative qualities of many materials. The material to be tested, e.g., pencil shavings, are placed loosely in the space between the small soup can and the larger coffee can.


thick cardboard lid (with slit through which thermometer can be inserted)
2 or 3 lb. coffee can
insulative material placed here
small soup can (6 oz. for example)
inverted styrofoam cup trimmed to size so that the top cardboard lid sits flush across the top of the two cans. (A piece of wood or cardboard, etc. might also be used as support.)
glue (will strengthen apparatus)

Equipment: Total equipment for class of 30

1. Six-two or three pound coffee cans, or cans of similar proportions for insulating containers
2. Six small soup cans (6 oz. for example)
3. Six cardboard lids about 12x12 inches or plastic lids from coffee can
4. Six thermometers
5. One clock that everyone can view
6. Six graphing materials
7. Six straightedges

8. One thermos or other insulative liquid container
9. One measuring cup (metric-where possible)
10. Drawings of thermometers
11. Glue
12. Insulating materials: pencil shavings, styrofoam, gravel, steel wool, sawdust, and other materials suggested by the children

Activity 1 - Readiness

Equipment: 1. Drawings of thermometers
2. Graph paper

Reading the thermometer with a degree of accuracy is very important in this investigation, so some students should spend some time practicing this skill. The lesson also requires that students plot data on a line graph. A learning center where students work independently at plotting temperature readings on a graph from illustrated thermometers would be one means of accomplishing this goal. A large model thermometer could be used.

Activity 2

Equipment: 1. One insulating box
2. Water
3. Graphing materials

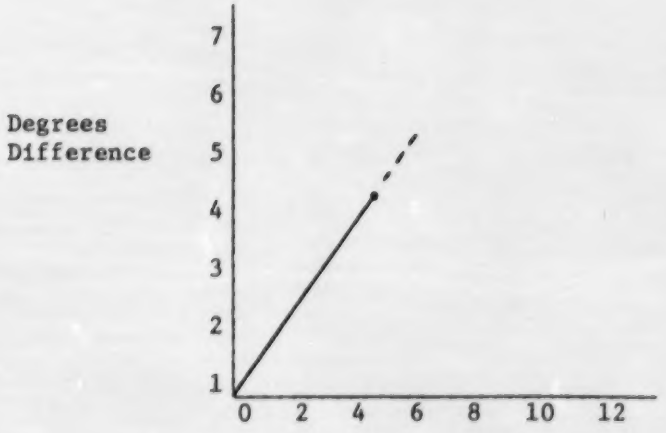
Place 75 millilitres (about three ounces) of water at 50°C. (about 120°F.) in the soup can that is placed in the insulating apparatus (Fig. 1) shown on page 3. The water must be at a level high enough to cover the bulb of the thermometer.

When the thermometer readers are satisfied that the liquid in the thermometer has reached its highest point, the timekeeper begins to time the temperature drop, the student at the blackboard begins to tabulate data (as shown on the following page) and class members record the temperature at the proper intervals on their individual sheets of graph paper. Read the thermometer at two-minute intervals for 10 or 12 minutes and continue to record the information on the graph.

Hypothetical Chart

Time	Temperature	Temperature Difference
0	49°C. (119°F.)	0 (0)
2 minutes	47°C. (115°F.)	2 (4°)
4	46°C. (112°F.)	1 (7°)
6		
8		
10		
12		

Hypothetical Graph



Heat Loss from Water
Over Period of Time

Using the information recorded on the graphs, assist students to interpret their data. There will probably be a rather constant slope of the line on the graph indicating that heat loss was rather constant during the time graphed. However, a one-degree drop during some two-minute intervals and a two-degree drop at others may be expected. Such deviations in data provide opportunities for students to offer a tentative explanation for the fluctuations, i.e., the rounding of numbers, reading errors and other factors contribute to such fluctuations.

After two or three readings have been plotted on the graph, ask the students to predict what the temperature is after ten minutes. It is important to remember that the prediction is just that: an estimate. A student's prediction could be somewhat in error, but his rationale for arriving at the predicted figure could be sound.

Activity 3

Equipment: All materials in the total equipment list

Now that your class has some information on heat loss, assist them in designing an experiment where they test the effect various materials have on the loss of heat energy from the warm water.

If the question, "How might we slow down the loss of heat energy from the can?" brings little response, try, "How does your winter clothing compare to the clothing you wear in summer?"

Using such materials as air, pencil shavings, or gravel, as well as other materials suggested by the children, test their insulating quality in the insulative apparatus (see Fig. 1). The testing could be done as follows:

First, test the insulative quality of the air around the small soup can in the insulative apparatus. (1) Measure 75 millilitres (about 3 ounces) of 50°C. (.20°F.) water in the soup can. (2) Place the lid on the insulation apparatus. (3) Push the thermometer through the slit in the lid and deep into the water. (4) At this point proceed as you did in Activity 2, read and record the temperature reading every two minutes once the temperature reading has reached its highest point. Record on chart as shown below (Fig. 3).

Next, test several more insulative materials, one at a time, following the same procedure as cited above, with one change. In the air space between the two cans in the insulation apparatus, place another insulative material, e.g., pencil shavings, and test the heat loss at each two-minute interval by reading the temperature.

Figure 3
Degrees Difference

		A	B	C	D	E
		air	gravel	cold water	shavings	
Minutes	0					
	2	1°C.(2°F.)	2°C.(4°F.)	3°C.(6°F.)	1°C.(2°F.)	
	4					
	6					
	8					
	10					
	12					

During each test, children should be challenged to control the experiments by keeping the water temperature, water quantity, can size, thermometers, etc. the same. The only change from test to test should be the material placed around the inner soup can in the insulating apparatus.

The classroom group could be organized into groups of five or six with each group choosing the material they wish to test. Each group could divide its responsibilities as illustrated below:

Chairman	Sharon
Timekeeper	Jeff
Thermometer Readers	Sue and Mark
Recorder	John
Grapher	Debbie

When each group has prepared its experiment with the insulation apparatus, the teacher should pour 75 millilitres (about 3 ounces) of water (preferably from a thermos where 50°C. (100°F.) water has been stored) into the small can. Each group should proceed to gather data as in Activity 2 and record it in a chart.

Activity 4:

Equipment: Chart from Activity 3

Some time will be needed to place the data from the five or six groups on the blackboard (or on a plastic sheet and shown on an overhead projector). The information on Figure 3 should be placed on a line graph so children can compare their findings.

Examining the data for younger children will probably not be as motivating as reading the thermometers and graphing. Older students

might wish to spend much time arriving at some conclusions. Conclusions would include such observations as: "They must have read the thermometer incorrectly." or "We may need to test some materials again."

Activity 5:

Equipment: Insulation apparatus

Each student could be challenged to select one material in his environment (not tested in the experiments) which he believes to be more insulative than air and one that is less, test it, then support or reject his prediction.

APPENDIX A

TV TEST OF SCIENCE PROCESSES

TEACHER'S TEST MANUAL

INTRODUCTION

This test is a modification of Dr. Robert Sher Tannenbaum's Test of Science Processes. It has been adapted for television presentation for the intermediate grades in an effort to assess the scientific skills and abilities that are emphasized in many of the modern science programs. Dr. Tannenbaum defines processes and the function of the test as:

"Processes" are ways of doing things. For example, scientists have to be able to look at things very carefully and tell what they see. Scientists have to be able to measure and use numbers. And, scientists have to be able to plan and understand experiments. This is a test of how well students can do some of the things scientists have to do. It is NOT a test of how many facts they know about science.

PREPARATION

Allow sufficient time before the scheduled TV presentation to prepare the students for the TV test. Following the introduction to Part I of the test, there will be two practice questions to show your students the test format followed immediately by the test questions. Be sure your students have the necessary materials prior to the TV presentation. They should have a pencil, a piece of scratch paper for doing any computations, an answer sheet, and a test booklet. Additional pencils and scratch paper should be accessible to the students. Do not allow the students to open the test booklet prior to the TV presentation. Do not "prime" the students in any way through your knowledge of the test questions as this will negate the test results. To help you regulate the time and reduce the chance of a period of inactivity prior to the TV presentation, you can have students fill in the necessary student identification information on the answer sheet until the presentation begins; and complete the information after the presentation.

TV PRESENTATION

Information regarding the time of the TV presentation of the Television Test of Science Processes will be given to you by your school district. The TV presentation will consist of two 30-minute programs given one week apart. Part I will include two practice questions and questions assessing the processes of classifying, observing, comparing, and quantifying. Part II will not repeat any of the practice questions or directions, but will include questions assessing the processes of measuring, inferring, experimenting and

and predicting. The programs will present all the information necessary for the questions, including the visual presentation as well as the audio presentation of the narration given in the test booklet.

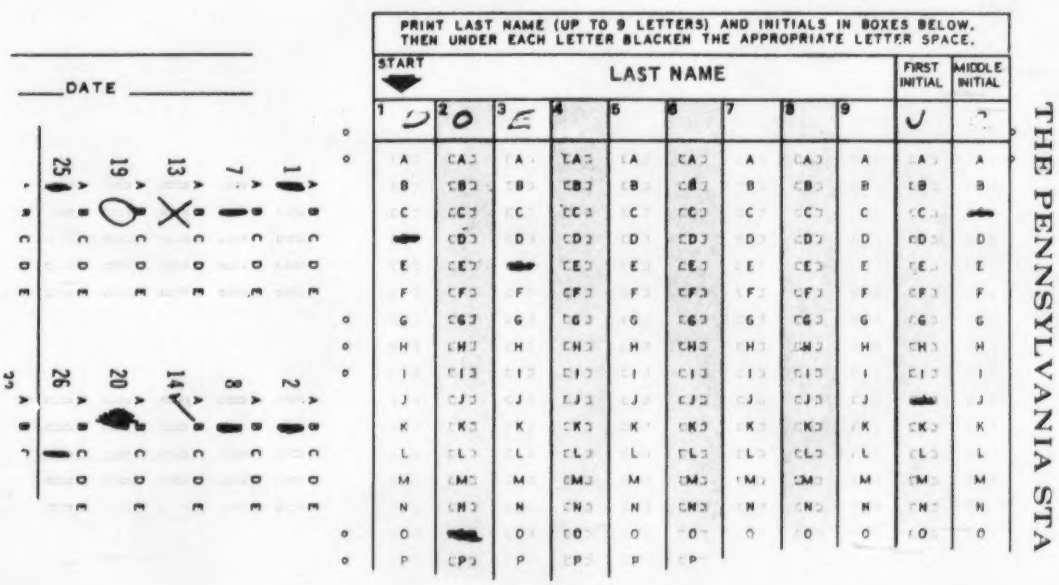
TEST BOOKLET

Inform students that they should not write in the test booklets. The test booklets contain the test questions and answer choices that are contained in the narration of the TV presentation. While there is no visual information on which to base answers, it is imperative that the students should not review any of the test questions prior to the formal presentation. This additional "cue" factor could invalidate the test results by introducing a reactive effect of interaction effect.

ANSWER SHEET

The answer sheet that is supplied is a machine-scored type. Instruct the students in the correct way to mark answers. The following diagram shows the correct way to fill out the name block. Answer spaces 13, 14, 19 and 20 are done incorrectly as an example of common mistakes often encountered with those not instructed in the use of this type of answer sheet.

Be sure to tell your students to choose only one answer for each question and to fill in the answer space with dark marks. If a student should change an answer, remind him to erase his first mark completely. If he breaks a pencil he is to hold up his hand and the teacher will give him a new one immediately.


DATE
PRINT LAST NAME (UP TO 9 LETTERS) AND INITIALS IN BOXES BELOW. THEN UNDER EACH LETTER BLACKEN THE APPROPRIATE LETTER SPACE.
START
LAST NAME
FIRST INITIAL
MIDDLE INITIAL
THE PENNSYLVANIA STA

PROCEDURE

There will be a single answer sheet for the two TV programs. Be sure to use a student identification number to identify the students. Collect the answer sheets and test booklets after each presentation and store in a safe place until they are requested.

DO NOT TURN THE PAGE UNTIL THE TEACHER TELLS YOU TO DO SO

TELEVISION TEST of SCIENCE PROCESSES

INTRODUCTION

This test is different than many of the tests you take. It will involve what you see on the television screen. Choose your answers from among the choices given in this booklet. Mark your choice on the special answer sheet.

Below are two practice questions. These will help you to understand what you are to do. Wait for the television introduction before you begin.

109. Here are 5 pieces of paper. Which piece of paper is both black and square?

A. 1
B. 2
C. 3
D. 4
E. 5

110. Here is a baseball on a sloping board. When the ball is released, what direction will the ball go?

A. up the board
B. down the board
C. stay where it is released
D. will rise in the air
E. both A and B (meaning both up and down the board)

DO NOT TURN THE PAGE UNTIL THE TEACHER TELLS YOU TO DO SO

1. This is a picture of 5 pieces of paper. Which statement identifies all the differences?

   A. 4 is a different color
   B. 2 is smaller
   C. 2 is smaller than all the others and 4 is a different color
   D. 1, 3, 4, and 5 are the same size
   E. 4 and 2 are different from each other

2. This is a picture of 8 pieces of paper. If you group them by shape, what is the smallest number of groups you can make?

   A. 1
   B. 2
   C. 3
   D. 4
   E. 5

3. Here are 7 toy airplanes. Airplanes 1, 2, 4, and 6 make up a special group. What does this group include?

   A. The planes that are modern jets
   B. The planes that are not black and are modern jets
   C. The planes that are black
   D. The planes that are not black
   E. The planes that are gray and white old-time 2-wing airplanes

4. This is a picture of pieces of paper which were left in the sun for different numbers of days. Which is the only thing you can say for sure, based on what you see in the picture?

   A. Sample 1 faded more than sample 2
   B. All paper will continue to fade forever the longer they are left in the sun.
   C. Any paper left in the sun will fade.
   D. Both samples faded more by day 5 than it had by day 2.
   E. Paper will fade in the sun, but cloth will not

5. This is a picture of 5 things. Which of them has volume?

   A. 1
   B. 2
   C. 3
   D. 4
   E. 5

6. There are two pots of water on a stove. Which choice is the best way of telling how they are different?

   A. The water is boiling in pot B
   B. The gas is on in pot B
   C. The water gets hot when the gas is on
   D. The water is not boiling in pot A
   E. The water is boiling in pot B, but it is not boiling in pot A

7. Here are 5 objects. Which of them is NOT in the same state of matter (solid, liquid, gas) as all the others?

   A. The pencil
   B. The water
   C. The toy whistle
   D. The ball
   E. The beads

8. This picture has 4 parts. Each part shows a compass, a bar magnet and a curved magnet. In which two parts are three things arranged in the same way?

   A. 1 and 3
   B. 2 and 4
   C. 1 and 4
   D. 2 and 3
   E. 1 and 2

9. Here are 5 objects. Which objects could serve as paper weights?

   A. 1, 3, 4 and 5
   B. 3 and 4
   C. 1, 2 and 5
   D. 2 and 5
   E. 2, 4 and 5

10. Here are 6 objects. Which objects can be used for carrying water?

    A. 1, 2, 3, 4 and 6
    B. 1, 2, 3 and 6
    C. 1, 2, 3, 4 and 5
    D. 1, 2, 5 and 6
    E. 1, 2, 3 and 5

11. Here are 10 marbles and 5 other objects. Which objects can be used to carry all 10 marbles at the same time?

    A. 1, 3 and 5
    B. 1 and 5
    C. 1, 3 and 4
    D. 1, 2 and 3
    E. 2, 3, 4 and 5

12. Which temperature reading is 25 degrees lower than 15° Fahrenheit?

    A. - 10° Fahrenheit
    B. 15° Fahrenheit
    C. - 25° Fahrenheit
    D. 0° Fahrenheit
    E. 40° Fahrenheit

13. This is a chart of information about 5 planets. Which of these planets has the longest year?

    A. Jupiter
    B. Saturn
    C. Mars
    D. Mercury
    E. Uranus

14. Look at the chart again. Which 2 planets have about the same length of day?

    A. Jupiter and Saturn
    B. Mars and Jupiter
    C. Mars and Uranus
    D. Mercury and Uranus
    E. No two

15. This is a graph of the boiling temperatures of 6 different liquids. Which liquid has the lowest boiling temperature?

    A. Liquid 1
    B. Liquid 2
    C. Liquid 3
    D. Liquid 5
    E. Liquid 6

16. Look at the graph again. Which liquids have the same boiling temperature?

    A. 4 and 6
    B. 3 and 4
    C. 1 and 5
    D. 1 and 2
    E. 3 and 5

17. Here is a ball. Which of these would be best for measuring the distance around this ball?

    A. Tape measure
    B. Meter stick
    C. Yard stick
    D. 1-foot ruler
    E. 6 inch ruler

18. Here are 2 clocks. In picture A, it is 3:40 in the afternoon. In picture B it is 6:10 that evening. How much later was picture B taken?

    A. 2 hours and 30 minutes
    B. 6 hours and 10 minutes
    3. 3 hours and 40 minutes
    D. 9 hours and 50 minutes
    E. 9 hours and 30 minutes

19. Which unit is used in expressing area?

    A. Inch
    B. Cubic centimeter
    C. Yard
    D. Square yard
    E. Meter

20. Which unit is used in measuring weight?

    A. Gram
    B. Kilometer
    C. Cubic centimeter
    D. Centimeter
    E. Meter

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TELEVISION TEST
of
SCIENCE PROCESSES
Part II

DO NOT TURN THE PAGE UNTIL THE TEACHER TELLS YOU TO DO SO

21. This is a picture of a box with its measurements shown on it. What is the area of the top of the box?

    A. 20 square inches
    B. 300 square inches
    C. 35 cubic inches
    D. 160 square inches
    E. 35 square inches

22. This is a marble and a ruler. If the marble rolls from point A to point B in 2 seconds at a steady speed, how fast is it going?

    A. 12 inches per 2 seconds
    B. 24 inches per second
    C. 2 feet per second
    D. 1/2 foot per second
    E. 1 foot per second

23. This is a picture of a box and 5 drawings. Which is the best drawing of the box?

    A. 1
    B. 2
    C. 3
    D. 4
    E. 5

24. Which unit is used in measuring length?

    A. Centimeter
    B. Gram
    C. Square yard
    D. Acre
    E. Quart

25. This is a map. How far is it from North Town to Birch Falls?

    A. 9 miles
    B. 18 miles
    C. 4 1/2 miles
    D. 27 miles
    E. 6 3/4 miles

26. Look at the map again. If you were using the same scale to draw another map, how far apart would you place two towns which are 5 miles from each other?

    A. 10 inches
    B. 2/5 inches
    C. 5 inches
    D. 15 inches
    E. 1 foot

27. In which pair are the units closest in size?

    A. Pound and kilometer
    B. Yard and meter
    C. Meter and mile
    D. Gram and liter
    E. Centimeter and foot

28. These are two ice cube trays. One is filled with very hot water and one with cold water. Many people say: "HOT WATER MAKES ICE CUBES QUICKER THAN COLD WATER." Plan an experiment to test this. Which choice would be the best statement for helping you?

    A. The hotter the water you start with, the faster it will freeze into ice cubes.
    B. Hot water freezes into ice cubes faster.
    C. Hot water freezes at higher temperatures than cold water.
    D. Hot water freezes into ice cubes faster because it turns on the refrigerator.
    E. Hot water makes steam - steam keeps the refrigerator going.

29. If you want to test the statement: "HOT WATER MAKES ICE CUBES QUICKER THAN COLD WATER." Which factor is the only one you should allow to change during the experiment?

    A. The temperature of the water you use.
    B. The amount of water in each tray.
    C. The position of the trays in the freezer.
    D. The refrigerator in which you put the trays.
    E. The kind of trays you use.

30. This is a graph of the results of an experiment. 200 seeds that were 10 years old and 200 new seeds were planted in good soil and watered each day.
    100 old seeds were put in a cool place
    100 old seeds were put in a warm place
    100 new seeds were put in a cool place
    100 new seeds were put in a warm place
    Five things which may affect the growth of the seeds are: water, heat, soil, age, and light. Which of these were tested?

    A. Heat and age only
    B. Soil, heat and light only
    C. Heat, soil, age and light only
    D. Water and soil only
    E. Water and age only

31. Look at the graph again. Here are some things you can see on the graph:
    1. 182 seeds sprouted
    2. 200 seeds were 10 years old
    3. 200 seeds were new
    4. 200 seeds were kept warm
    5. 200 seeds were kept cool

    Which one happened because of all the others?

    A. 1
    B. 2
    C. 3
    D. 4
    E. 5

32. Here are 5 containers which will be left out in a thunder storm. Which is the best container to use to find out how many inches of rain will fall?

    A. 1
    B. 2
    C. 3
    D. 4
    E. 5

33. Here are 4 screws and 4 magnets. Which statement CANNOT be made just from looking at the picture?

    A. Screws 2 and 3 have big heads.
    B. Screws 2 and 3 are sticking to their magnets.
    C. Some screws are made from a metal which is not magnetic.
    D. All the screws with big heads in this picture are sticking to their magnets.
    E. Screws 1 and 4 are not sticking to their magnets.

34. Here is some string. The manufacturer claims it will hold at least 100 lbs. What is the best way to check this?

    A. Hang a weight of 75 pounds on the string, and keep adding 1-pound weights until it breaks.
    B. Hang a 100-pound weight on the string and see if it breaks.
    C. Let two 100-pound boys pull on each end of a piece of the string and see if it breaks.
    D. Hang 101 pounds on the string and see if it breaks.
    E. Double the string and hang 50 pounds from it, and see if it breaks.

35. This is a chart of the change in length of a metal bar as it is heated. What is its length at 40° C.?

    A. 101 centimeters
    B. 101.5 centimeters
    C. 102 centimeters
    D. 102.5 centimeters
    E. 103 centimeters

36. Look at the chart again. What will the length of the bar probably be at 100°C.?

    A. 103.5 centimeters
    B. 104 centimeters
    C. 104.5 centimeters
    D. 105 centimeters
    E. 105.5 centimeters

37. What is the best way to check the answers to the last two questions?

    A. Measure the bar at 100° C. and then graph all the numbers to check your answers.
    B. Measure the bar at 120° C. and then make a graph of all the numbers to check your answers.
    C. Put all your answers on the chart and see if they look correct.
    D. Measure the bar at least 5 times at other temperatures and compare what you find with your answers.
    E. Measure the bar at 40° C. and at 100° C. and compare what you find with your answers.

38. These are 2 pictures of a battery, a bulb, a switch, and some wires. Which is the only thing you can be sure is different between the pictures?

    A. The bulb was replaced for picture 2.
    B. The wires were tightened for picture 2.
    C. The bulb was screwed in for picture 2.
    D. The battery was electrically recharged for picture 2.
    E. Electricity is flowing through the bulb in picture 2.

39. If you want to prove that "NOT ALL THINGS GET BIGGER AS YOU HEAT THEM," What would you need to do?

    A. Find one thing that does not get bigger when it is heated.
    B. Find all the things that do not get bigger when they are heated.
    C. Find one thing that gets bigger when it is heated.
    D. Find all the things that get bigger when they are heated.
    E. Find all the things that do not change size when they are heated.

40. If you want to make this statement: "THE COLDER A CITY IS, THE MORE SNOW IT HAS," What do you need to know about some cities?

A. The average temperature of each city and the number of snow plows each has.
B. The number of days school was closed in each city because of snow.
C. The average temperature and precipitation of each city.
D. The average temperature and average snowfall of each city.
E. The average number of times it snows in each city.